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NATIONAL DAM SAFETY PROGRAM. LAKE OF THE WOODS, INVENTORY NUMBE--ETC(U)
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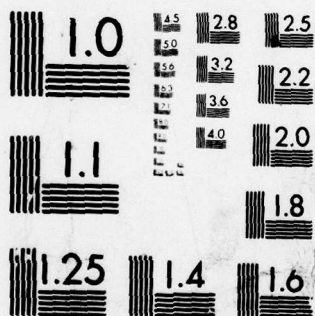
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MICROCOPY RESOLUTION TEST CHART
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RAPPAHANNOCK RIVER BASIN

Name Of Dam: Lake of the Woods

Location: Orange County, State of Virginia

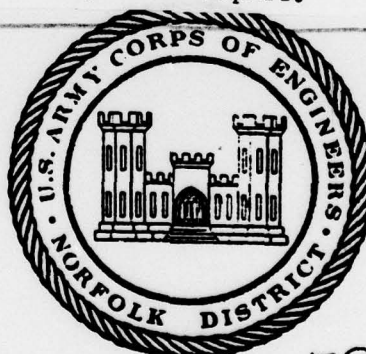
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PHASE I INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

Lake of the Woods, Inventory Number:
VA13701. Rappahannock River Basin,
Orange County, State of Virginia.
Phase I Inspection Report.

9 Final rept.



10 Michael Baker, III

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PREPARED FOR

NORFOLK DISTRICT CORPS OF ENGINEERS

803 FRONT STREET

NORFOLK, VIRGINIA 23510

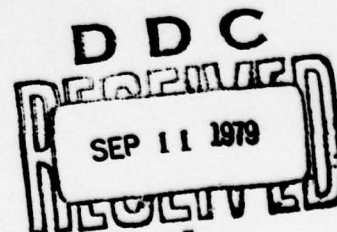
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20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam and appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the design flood should not be interpreted as necessarily posing a highly inadequate condition. The design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

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NAME OF DAM: LAKE OF THE WOODS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam: Lake of the Woods
State: Virginia
County: Orange
Stream: Flat Run
Date of Inspection: 29 November 1978

BRIEF ASSESSMENT OF DAM

Lake of the Woods Dam is an earthen dam approximately 65 feet high and 1475 feet long. The dam is owned, operated, and maintained by Lake of the Woods, Inc. and was designed by Bauer Engineering, Inc. The lake is used for recreation by Lake of the Woods residents. The visual inspection and review of engineering data, made in November 1978 and January 1979, indicate no deficiencies requiring emergency attention.

The spillway will pass 67 percent of the Probable Maximum Flood without overtopping the dam, which is considered inadequate but not seriously inadequate for the "intermediate" size-"high" hazard classification of Lake of the Woods Dam. Review of stability calculations and visual observations made in the field indicate no evidence of embankment instability or piping of an emergency nature. However, if an emergency condition developed that would require draining the reservoir; the inability of the reservoir drain to empty the reservoir in a reasonable period of time is considered an undesirable condition. A study should be instituted immediately to determine an alternate method to drain the reservoir.

It is recommended that the finger drain outlets at the toe be located and opened into the drainage channel along the toe of the dam. The epoxy patches in the spillway that are no longer adhering to the concrete should be repaired, especially around the sluice gate. Rock should be placed over the seepage and erosion area at the end of the right spillway wall beside the stilling basin. The area behind the left spillway wall, where settlement has occurred, should be filled with soil, compacted, and seeded. The following minor maintenance items should be accomplished as part of the yearly maintenance program: fill and seed bare areas on the embankment, remove small trees from the drainage ditch at the toe, replace dislodged or missing riprap, remove

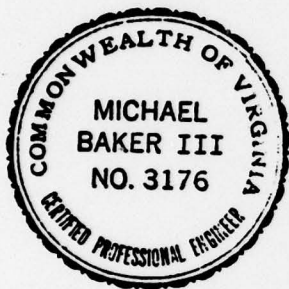
NAME OF DAM: LAKE OF THE WOODS

any large debris from the reservoir area and spillway, and install a staff gage to monitor reservoir levels above normal pool.

MICHAEL BAKER, JR., INC.



Michael Baker, III, P.E.
Chairman of the Board and
Chief Executive Officer



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Chief, Design Branch

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Zane M. Goodwin
Chief, Engineering

APPROVED:

Douglas L. Haller
Douglas L. Haller
Colonel, Corps of Engineers
District Engineer

Date:

MAR 19 1979

NAME OF DAM: LAKE OF THE WOODS



OVERALL VIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
NAME OF DAM: LAKE OF THE WOODS ID# VA 13701

SECTION 1 - PROJECT INFORMATION

1.1 General

- 1.1.1 Authority: Public Law 92-367, 8 August 1972 authorized the Secretary of the Army, through the Corps of Engineers to initiate a national program of safety inspections of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.
- 1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams. The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Description of Project

- 1.2.1 Description of Dam and Appurtenances: Lake of the Woods Dam is a homogeneous earthfill dam approximately 1475 feet long and 65 feet high. Seepage control is provided by an 8 inch perforated C.M.P. which extends from abutment to abutment along the base of the dam approximately 30 feet downstream from the centerline (see Plate 2). A cutoff trench and filter drains provide additional seepage control at the downstream toe and beneath 12 inches of riprap on the upstream face.
- The overflow spillway located in the left abutment area consists of a concrete ogee weir, 40 feet long and 6.5 feet high, with a paved chute spillway, approximately 135 feet long on a 3 horizontal to 1 vertical (3:1) slope. All outflow from the dam is through this overflow spillway. The chute spillway discharges into a 30 foot wide by 65 foot long stilling basin. The weir crest elevation is 317.5 feet M.S.L.
- A two-foot-square sluice gate is located at the left end of the concrete weir and is used primarily to flush sediment that accumulates behind the weir.

NAME OF DAM: LAKE OF THE WOODS

The lake can be drained by means of a 12 inch ductile iron drainpipe which extends through the dam and outlets into a small stream at the downstream toe of the dam. The drain is controlled by a 12 inch plug valve located about 15 feet upstream of its outlet. The plan and typical sections of the dam are shown on Plates 1, 2, and 3.

- 1.2.2 Location: Lake of the Woods Dam is located on Flat Run just upstream of Virginia State Route 3, 7 miles northwest of Chancellorsville, Orange County, Virginia. A Location Plan is included in this report.
- 1.2.3 Size Classification: The maximum height of the dam is 65 feet above the old streambed of Flat Run. The reservoir volume to the top of the dam is 14,160 acre-feet. Therefore, the dam is in the "intermediate" size category as defined by the Recommended Guidelines for Safety Inspection of Dams.
- 1.2.4 Hazard Classification: A treatment plant is located in the floodplain approximately 0.4 mile downstream from the dam. Because of the proximity of this plant, loss of life could result in the event of failure of the dam. Therefore, the dam is considered in the "high" hazard classification as defined by Section 2.1.2 of the Recommended Guidelines for Safety Inspection of Dams. The hazard classification used to categorize dams is a function of location only and has nothing to do with its stability or probability of failure.
- 1.2.5 Ownership: Lake of the Woods Dam which is situated in a private residential community is owned, operated, and maintained by Lake of the Woods, Inc.
- 1.2.6 Purpose: Lake of the Woods Dam is a privately owned recreational facility.
- 1.2.7 Design and Construction History: The existing facility was designed for the owner by Bauer Engineering, Inc. of Chicago, Illinois and constructed by Shoosmith Bros., Inc.

NAME OF DAM: LAKE OF THE WOODS

1.2.8 Normal Operational Procedures: No formal operational procedures are followed for this dam since it is a recreational facility. Normal pool elevation of 317.5 feet M.S.L. is maintained by a concrete ogee overflow weir that is the only spillway. The two-foot-square sluice gate and the 12 inch reservoir drain are opened annually to flush out sediment deposits.

1.3 Pertinent Data

1.3.1 Drainage Area: The drainage area of the Lake of the Woods Dam is 7.23 square miles.

1.3.2 Discharge at Dam Site: The maximum discharge through the spillway is not known.

Spillway:

Pool level at top of dam 3801 c.f.s.

1.3.3 Dam and Reservoir Data: Pertinent data on the dam and reservoir are shown in the following table:

TABLE 1.1 DAM AND RESERVOIR DATA

| Item | Elevation feet M.S.L. | Area acres | Reservoir Capacity | | Length feet |
|-----------------------------------|--------------------------|---------------|-----------------------|---------------------|----------------|
| | | | Acre- feet | Watershed inches | |
| Top of dam | 325.0 | 625 | 14,160 | 36.7 | 14,600 |
| Spillway crest | 317.5 | 500 | 9880 | 25.6 | 13,400 |
| Streambed at centerline of dam | 260+ | - | - | - | - |

NAME OF DAM: LAKE OF THE WOODS

SECTION 2 - ENGINEERING DATA

2.1 Design: The design data reviewed included the following:

- 1) As-built drawings of the dam including plan, elevation, typical sections, structural details, boring logs, and test pits.
- 2) Partial construction report documents including revisions that were made to the side slopes and compaction requirements (Appendix V).
- 3) Final inspection report by the designer, Bauer Engineering, Inc., at time of construction completion (Appendix V).
- 4) Partial hydraulic and hydrologic design data by Bauer Engineering, Inc., including a flood routing for Probable Maximum Flood (PMF), was reviewed and is discussed further in Section 5.1.
- 5) Soils exploration reports by Dames and Moore (Appendix VI).
- 6) Stability analyses by Dames and Moore, and Bauer Engineering, Inc. are discussed further in Section 6.2.2 (Appendix VII).

All design data reviewed was borrowed from the owner.

2.2 Construction: The dam was built by the Shoosmith Bros., Inc. and was completed in March 1968. As-built drawings, change orders, and material requisitions were available for review. The as-built drawings were verified in the field.

According to correspondence reviewed from the owner's file; it is apparent that during construction of the embankment, 95% of modified density was difficult to maintain. It was decided that, although 95% compaction would be strived for, a lower limit for compaction of 92% to 93% would be permissible. Dames and Moore of Chicago, Illinois, performed field explorations and laboratory tests during construction. With the relaxation of compaction requirements, it was decided to flatten the final slopes to 4:1 upstream and 3.5:1 downstream. These were the final slopes as indicated on the as-built drawings. The final inspection of the dam, spillway, and appurtenant structures was made by the design engineer on 6 March 1968.

NAME OF DAM: LAKE OF THE WOODS

- 2.3 Operation: There is no formal operating procedure for this dam. However, the two-foot-square sluice gate located in the spillway is operated on an annual basis to flush out sediment deposits as is the 12 inch reservoir drain.

The filling of the reservoir commenced in 1967 according to the report by E. D'Appolonia in October 1969 (Appendix V, pp. 5-18). Although there was some concern about the "slow rate of filling of the reservoir," D'Appolonia felt that additional filling time should be allowed before concluding the lake would not reach its normal pool elevation without expensive remedial or artificial filling measures.

Bauer Engineering, Inc. conducted an inspection (see report and check list in Appendix V) in August 1970 at the request of the developer, Boise Cascade Corporation, and stated that in general the dam appeared to be in excellent condition.

2.4 Evaluation:

- 2.4.1 Design: The as-built drawings were adequate to aid in the assessment of the stability of the dam. Stability calculations for the earthen section of the dam are included in Appendix VII. Design calculations for different conditions were available for the concrete weir and adjoining retaining walls of the spillway.
- 2.4.2 Construction: The construction reports and correspondence reviewed indicated that construction methods used were in accordance with design criteria.
- 2.4.3 Operation: Operations performed by Lake of the Woods personnel are considered adequate for this structure.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

3.1.1 General: The field investigation was made on 29 November 1978. The weather was cloudy and rainy. The lake was at elevation 317.0 feet M.S.L. (0.5 foot below normal pool). The embankment and the appurtenant structures were found to be in good overall condition and do not require immediate remedial action.

3.1.2 Dam: The embankment was in good condition except for small areas on the crest and downstream face which have sparse topsoil and vegetation. These areas should be topsoiled and seeded. There is scattered driftwood on the riprap which should be removed. The stone riprap dislodged in a few small areas should be replaced.

The wet areas at the toe of the dam and on the slopes of the collection ditch nearby are probably caused by the finger outlets from the filter drain being partially blocked by topsoil. The outlets should be cleaned out and extended to the ditch where necessary. Trees growing in the ditch and dumped tree stumps should be removed.

3.1.3 Appurtenant Structures: The intake portion of the reservoir drain is submerged. The plug valve and outlet pipe appear to be in good condition. There was no flow from the outlet pipe (Photo 1).

The concrete spillway functions adequately in spite of minor deterioration which includes epoxy patching in nine areas with clear leakage at two locations. There are small popouts of aggregate on the crest of the weir and in the spillway. Minor settlement (less than 2 feet) of the backfill adjacent to the left (north) wall should be corrected by the addition of compacted soil and seeding. The clear seepage and eroded area at the end of the right wall beside the stilling basin should be covered with rock to prevent further erosion. There is some clear leakage in the patched stem of the weir adjacent to the slide gate. Photos 2-6 show the deterioration of the spillway.

NAME OF DAM: LAKE OF THE WOODS

3.1.4 Reservoir Area: The slopes in the reservoir area are apparently well vegetated with minor erosion.

3.1.5 Downstream Channel: The outlet channels for the reservoir drain and spillway are in satisfactory condition. There is some minor erosion on the slopes where clear seepage is present downstream from the spillway.

3.2 Evaluation: None of the above items is serious enough to represent an emergency condition. However, the following items should be completed within a year from the date of this report. Erosion control and seeding of bare areas should be included in the annual inspection and maintenance program. The repair of the filter drain outlets, elimination of trees growing in the downstream drainage ditch, removal of the pile of tree stumps, and repairs in the spillway area should also be completed.

NAME OF DAM: LAKE OF THE WOODS

SECTION 4 - OPERATIONAL PROCEDURES

- 4.1 Procedures: Operational procedures are generally discussed in paragraphs 1.2.8 and 2.3. The owner opens the slide gate on the face of the concrete weir in the spillway and the reservoir drain annually to flush out sediments.
- 4.2 Maintenance of Dam: Maintenance of the dam is provided by personnel of Lake of the Woods, Inc.
- 4.3 Maintenance of Operating Facilities: Maintenance of the operating facilities is also provided by the owner. As previously mentioned, the slide gate on the weir in the spillway and the reservoir drain are operated and checked annually.
- 4.4 Warning System: At the present time, there is no formal warning system or evacuation plan in operation. It is recommended that a formal emergency procedure be prepared and prominently displayed, and furnished to all operating personnel. This should include:
- 1) How to operate the dam during an emergency.
 - 2) Who to notify, including public officials, in case evacuation from the downstream area is necessary.
 - 3) Procedures for evaluating inflow during periods of emergency operation.
- 4.5 Evaluation: Operational procedures are considered adequate for the existing facilities at Lake of the Woods Dam.

NAME OF DAM: LAKE OF THE WOODS

SECTION 5 - HYDRAULIC/HYDROLOGIC DATA

5.1 Design: Partial hydrologic and hydraulic design calculations were obtained from the owner. According to the design calculations, dated October 1966, by Bauer Engineering, Inc., the dam and spillway will pass the PMF with a maximum reservoir elevation of 324.2 feet M.S.L. The spillway discharge capacity was computed by Bauer Engineering, Inc. using a weir coefficient of 4.0 for all reservoir heads and a weir length of 50 feet. This would yield a maximum discharge at the top of dam elevation of approximately 4100 c.f.s.

5.2 Hydrologic Records: No rainfall or stream flow records were available at the dam.

5.3 Flood Experience: No records of high stage were available for this report. However during the heavy rains of July 1969, the reservoir was being filled and rose an additional 6 inches as a result of this rainfall. (Appendix V, p. 10.)

5.4 Flood Potential: Performance of the dam and reservoir by routing the PMF, the 1/2 PMF, and the 100-year flood is shown in Table 5.1.

Surface area and storage capacity data were obtained from the design data. Outlet discharge capacity hydrograph and routing determinations were computed as part of this report for comparison with design assumptions and calculations. Flood routings were started assuming the reservoir level was at normal pool (elevation 317.5 feet M.S.L.).

5.5 Reservoir Regulation: Pertinent dam and reservoir data are shown in Table 1.1, paragraph 1.3.3.

Regulation of flow from the reservoir is automatic under normal conditions. Normal pool (elevation 317.5 feet) is maintained by the crest of the overflow weir in the spillway. Normal outflow from the reservoir passes through this spillway, except for flow through the reservoir drain and slide gate when opened.

5.6 Overtopping Potential: The overtopping potential was evaluated by combining three separate inflow hydrographs for each flood analyzed. One inflow hydrograph represented inflow produced by direct runoff from rainfall over the lake surface area of 0.78 square mile. A second inflow hydrograph represented 3.40 square miles of

NAME OF DAM: LAKE OF THE WOODS

watershed in the upper regions of the watershed, which was lagged 2 hours based on travel time behind the lake runoff hydrograph. A third inflow hydrograph represented the remaining 3.05 square miles of watershed, which included primarily the watershed around the lake. This watershed, having a short time of concentration, was lagged only 0.5 hour behind the lake runoff hydrograph. These three hydrographs were combined and routed through the reservoir to determine the outflow hydrograph.

The probable rise in the reservoir and other pertinent information on the reservoir performance in various hydrographs are shown in the following table:

TABLE 5.1 RESERVOIR PERFORMANCE

| Item | Normal | Hydrographs | | |
|----------------------------------|--------|-------------|---------|--------|
| | | 100 Year | 1/2 PMF | PMF |
| Peak flow, c.f.s. | | | | |
| Inflow | - | 5996 | 12,609 | 25,218 |
| Outflow | - | 543 | 2769 | 13,804 |
| Peak elev., ft. M.S.L. | 317.5 | 319.6 | 323.6 | 326.7 |
| Spillway | | | | |
| Depth of flow, ft. (a) | - | 1.4 | 4.1 | 6.1 |
| Avg. velocity, f.p.s. | - | 6.5 | 11.4 | 14.0 |
| Non-overflow section | | | | |
| Depth of flow, ft. | - | - | - | 1.7 |
| Average velocity, f.p.s. | - | - | - | 3.5 |
| Duration of overtopping, hrs. | - | - | - | 6.3 |
| Tailwater elev., ft. M.S.L. | 262.0 | - | - | - |

(a) Estimated depth at ogee weir based on critical depth.

5.7 Reservoir Emptying Potential: Neglecting inflow, the reservoir elevation may be lowered from normal pool (elevation 317.5 feet M.S.L.) to elevation 310.5 feet M.S.L. in approximately 45 days by use of the two-foot-square, sluice gate outlet on the face of the weir and the 12 inch diameter reservoir drain. The reservoir below the sluice gate invert of elevation 310.5 feet M.S.L. can only be lowered by use of the reservoir drain with a maximum discharge (pool level at elevation 310.5 feet M.S.L.) of 11 c.f.s. Again neglecting inflow, it would take 1 year to lower the reservoir from elevation 310.5 feet M.S.L. to the invert of the

NAME OF DAM: LAKE OF THE WOODS

reservoir at elevation 275.0 feet M.S.L. In the event of an emergency, the reservoir could not be emptied in a reasonable time because of the small size of the reservoir drain (12 inch diameter pipe).

- 5.8 Evaluation: Lake of the Woods Dam is classified according to COE criteria as an "intermediate" size-"high" hazard structure requiring passage of a spillway design flood equal to the PMF. The spillway will only pass about 67% of the PMF without overtopping.

However according to design data computed by Bauer Engineering, Inc., the spillway will pass the PMF with a maximum reservoir elevation about 0.8 foot below the top of dam. The differences between the computations for the design and the computations completed as part of this report can probably be attributed to methods of analyses, difference in weir length of spillway, and difference in peak and volume of hydrographs. The peak used for the design hydrograph was 19,300 c.f.s. compared to the 25,200 c.f.s. used for the hydrograph listed in Table 5.1. The assumptions used in computing the design hydrograph are not known.

Therefore, the hydrographs computed as part of this report (shown in Table 5.1) were used in the evaluation of the spillway adequacy because they were considered to more accurately depict the actual conditions found in the field.

The inability to empty the reservoir in a reasonable period of time is considered undesirable and an alternate means of draining the reservoir during an emergency condition should be investigated.

Conclusions pertain to present day conditions and the effect of the future development on hydrology has not been considered.

NAME OF DAM: LAKE OF THE WOODS

SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: There is 3 feet of alluvial, silty sand and gravel (SP/GP) in the bottom of the stream valley with 5 to 8 feet of sandy silt at higher elevations nearer the base of the hills overlying gray, highly weathered gneiss. The slopes in the abutment area are covered by 5 feet of reddish-brown, clayey silt overlying brown and gray, sandy silt with rock fragments (decomposed rock) to a maximum depth of 50 feet. The top of the bedrock is gray and brown, highly weathered gneiss.

6.2 Stability Analysis

6.2.1 Visual Observations: No evidence of instability in the embankment, cut slopes, or concrete structures was observed. The only deficiencies observed were the partial settlement of the backfill adjacent to the left wall of the concrete spillway, and clear seepage and erosion at the end of the wall on the right side (see Photo 6). The flow, from the filter drain and clear seepage in the vicinity of the toe of the dam and parallel drainage ditch, occurs in several areas to the right of the reservoir drain outlet apparently from the covered granular finger outlets. The flow from the collector ditch into the stilling basin for the spillway was measured at 4 g.p.m., which was not considered excessive.

6.2.2 Design Data: The slope stability was checked in 1967 by the Swedish Circle Method for the homogeneous dam embankment. The analysis was computed by Dames and Moore. The embankment section chosen for these analyses had a crest elevation of 325.0 feet M.S.L., upstream slope of 4:1 ratio, and a downstream slope of 3:1. The following shear strength parameters were assumed for the foundation and embankment soils:

| | ϕ | C (p.s.f.) | Unit Weight (p.c.f.) |
|------------------------|--------|---------------|-------------------------|
| Homogeneous Embankment | 20° | 200 | 115 |
| Foundation (Assumed) | 28° | 300 | 120 |

NAME OF DAM: LAKE OF THE WOODS

The shear strengths for the embankment were determined from the consolidated, saturated, undrained, triaxial shear and direct shear tests. The embankment soil on the slopes was assumed to be saturated. The homogeneous soil was assumed to be compacted to 90% of the maximum dry density. The parameters of the foundation soil immediately underlying the embankment were assumed. The minimum safety factors computed by Dames and Moore for the homogeneous embankment were 1.66 for the upstream slope and 1.35 for the downstream slope. Computations for the downstream slope assumed steady seepage with a straight phreatic line extending from the water level (equal to the spillway crest) on the upstream slope to the filter drain which is based on an adequate performance of the drain. The filter drain is located on the foundation just downstream from the crest.

The upstream slope was also checked at a later date by Bauer Engineering, Inc. A factor of safety of 1.726 for an upstream slope of 3:1 was calculated by the method of slices for a 0.05g seismic factor.

There was no available explanation for the different slope stability criteria used by the two consultants.

The stability analyses data are presented in Appendix VII.

- 6.2.3 Operating Records: The reports of several inspections of the dam from 1969 to 1972 by engineering firms are included in Appendix V. A few clear seepage zones in the vicinity of the toe of the dam were observed along with erosion areas, slow filling of the reservoir due to possible water loss, clear leakage through cracks in the spillway, and other minor conditions. Remedial measures were recommended for the deficiencies and some were undertaken by the owner, as indicated by the epoxy patching applied to the cracks in the concrete weir.
- 6.2.4 Post-Construction Changes: No significant alterations to the dam were apparent since it was constructed.

NAME OF DAM: LAKE OF THE WOODS

6.2.5 Seismic Stability: Lake of the Woods Dam is located in Seismic Zone 2 near the line of demarcation with Seismic Zone 1. Therefore, it is considered to have no hazard from earthquakes according to the Recommended Guidelines for Safety Inspection of Dams, provided static stability conditions are satisfactory and conventional safety margins exist.

6.3 Evaluation: The embankment section chosen is similar to the as-built drawings except the downstream slope was constructed at a 3.5:1 ratio which would result in a higher safety factor than previously calculated (1.35) for steady state seepage with headwater at the spillway crest. None of the available calculations indicate that stability under rapid drawdown conditions was performed. The 4:1 slope on the upstream side is usually adequate except in cases where the soil strength is extremely low, which is not the case for Lake of the Woods Dam based on available information. However, good engineering practice requires that stability under rapid drawdown should be examined.

NAME OF DAM: LAKE OF THE WOODS

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

- 7.1 Dam Assessment: The dam will pass approximately 67% of the PMF without overtopping which is considered inadequate but not seriously inadequate according to criteria established by the Recommended Guidelines for the Safety Inspection of Dams for an "intermediate" size-"high" hazard category.

Stability analyses were available (Appendix VII) for review. The stability analyses indicated sufficient factors of safety. No evidence of sloughing or seepage indicating embankment distress was observed during the field inspection. The embankments appeared uniform in section with no bulging or areas of depression evident. The grass cover on the embankments was in good condition with the exception of a few small bare areas.

The spillway appears to be functioning adequately. Epoxy patching is leaking (clear) in several places on the weir. There are also small popouts of aggregate on the crest of the weir and in the spillway. These items are not considered to deter proper spillway operation.

- 7.2 Recommended Remedial Measures: It is recommended that continued maintenance of the concrete surfaces in the spillway be provided. The clear leaks in the weir and around the slide gate should be patched where the old epoxy patching is no longer adhering to the concrete.

An alternate means of draining the reservoir in case of an emergency should be investigated immediately by a consultant since the reservoir cannot be drained in a reasonable period of time. In addition, the stability of the upstream slope under rapid drawdown should be examined.

The finger outlets from the filter drain should be located, cleaned, and extended to the drainage ditch along the toe of the dam. The drainage ditch should be cleaned of the tree stumps and other debris, and maintained to provide adequate drainage away from the dam.

The inspection revealed certain preventative maintenance items which should be scheduled as part of an annual maintenance program. These are:

- 1) Rock should be placed over the seepage and erosion area at the end of the right spillway wall beside the stilling basin.

NAME OF DAM: LAKE OF THE WOODS

- 2) The area behind the left wall of the spillway where settlement has occurred should be filled with compacted soil and seeded.
- 3) Fill and seed all bare areas on the embankment.
- 4) Remove all trees along the drainage ditch at the toe of the dam.
- 5) Replace any dislodged or missing riprap along the upstream embankment and approach channel to the spillway.
- 6) Remove all driftwood and other debris from the reservoir area.
- 7) Install a staff gage to monitor reservoir levels above normal pool.

NAME OF DAM: LAKE OF THE WOODS

APPENDIX I

PLATES

CONTENTS

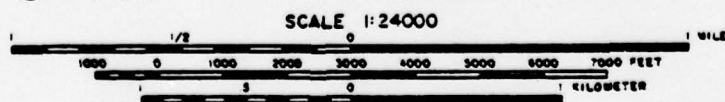
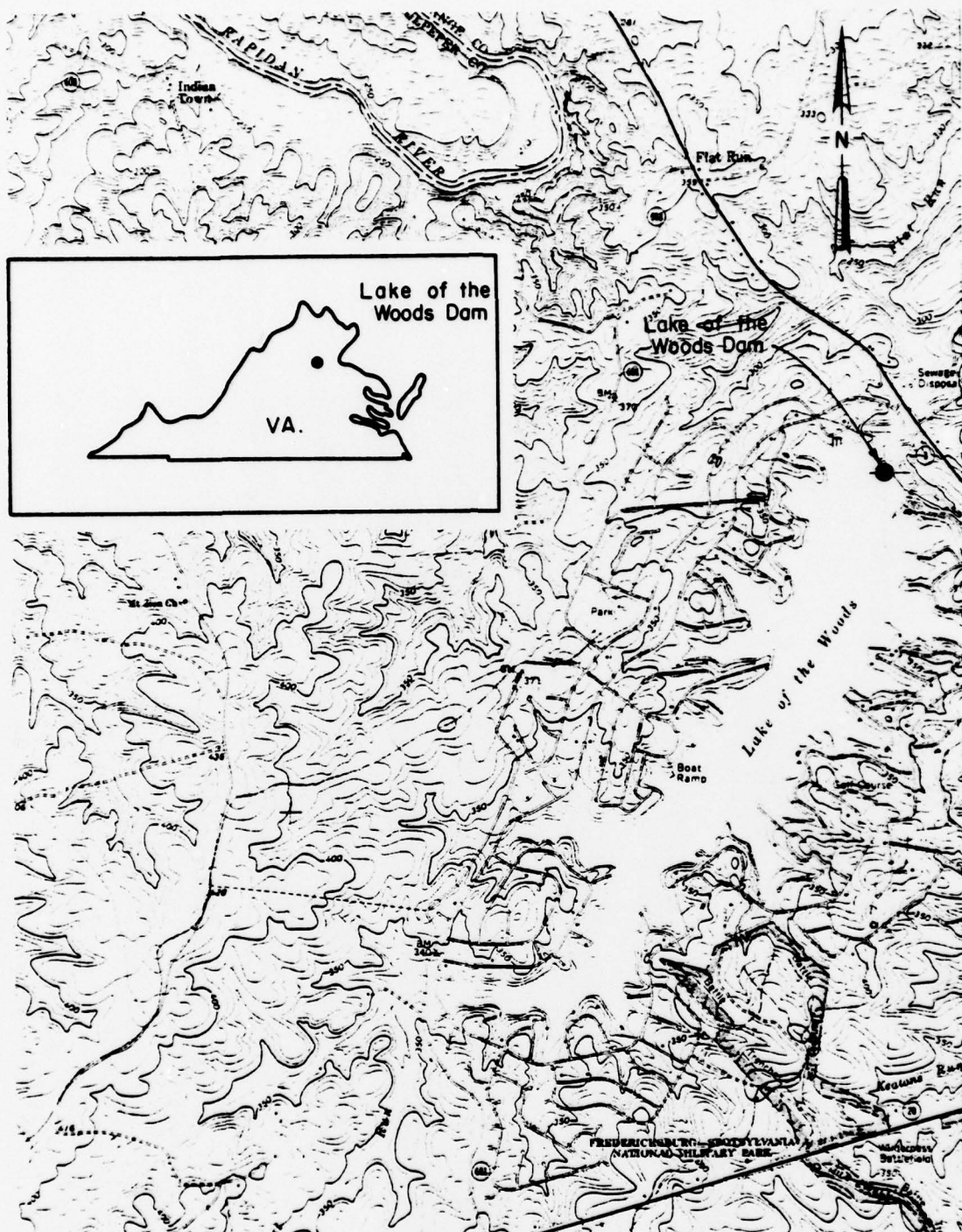
Location Plan

Plate 1: General Plan of Dam and Spillway

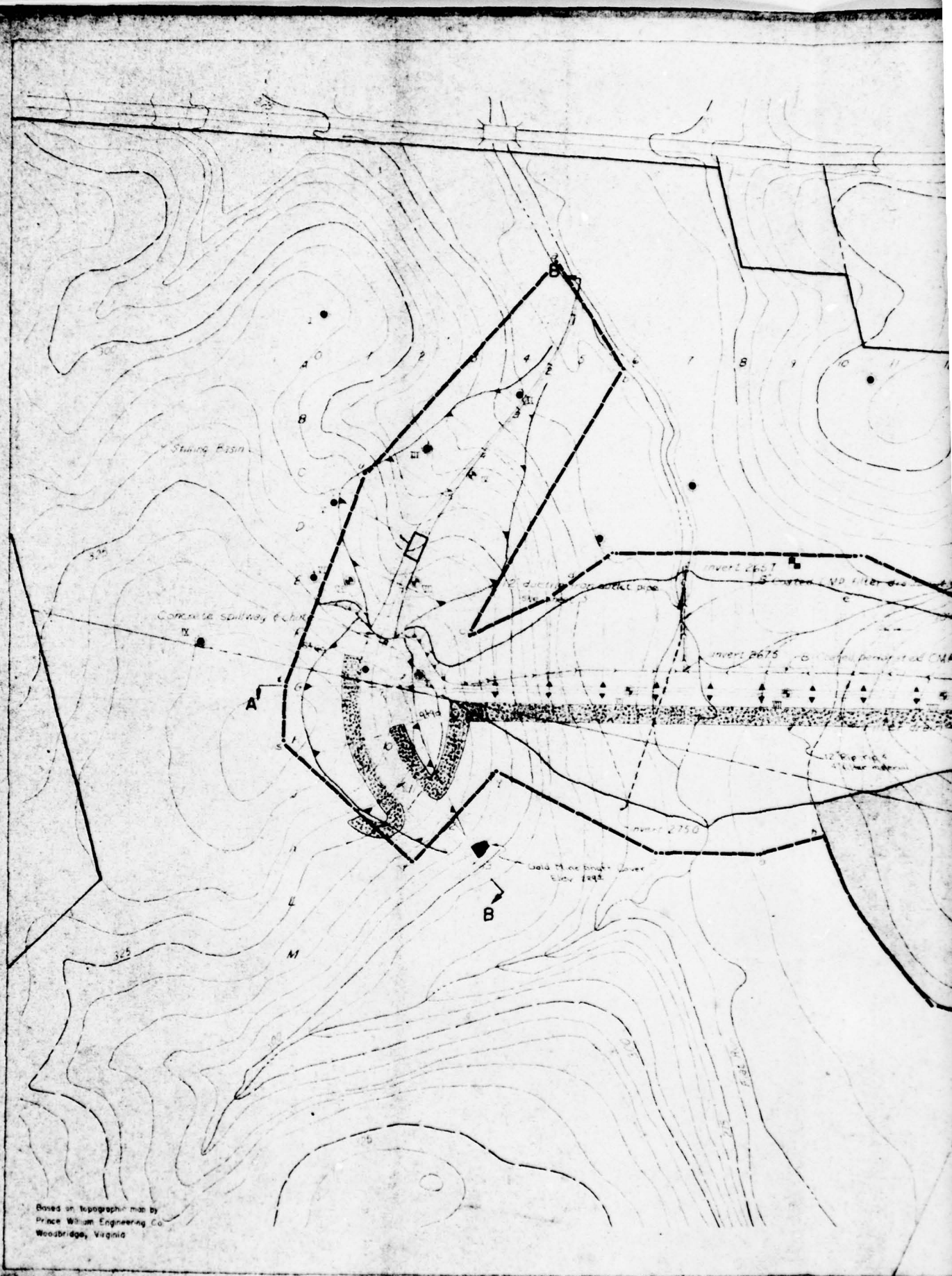
Plate 2: Sections of Dam

Plate 3: Plan and Profile of Spillway

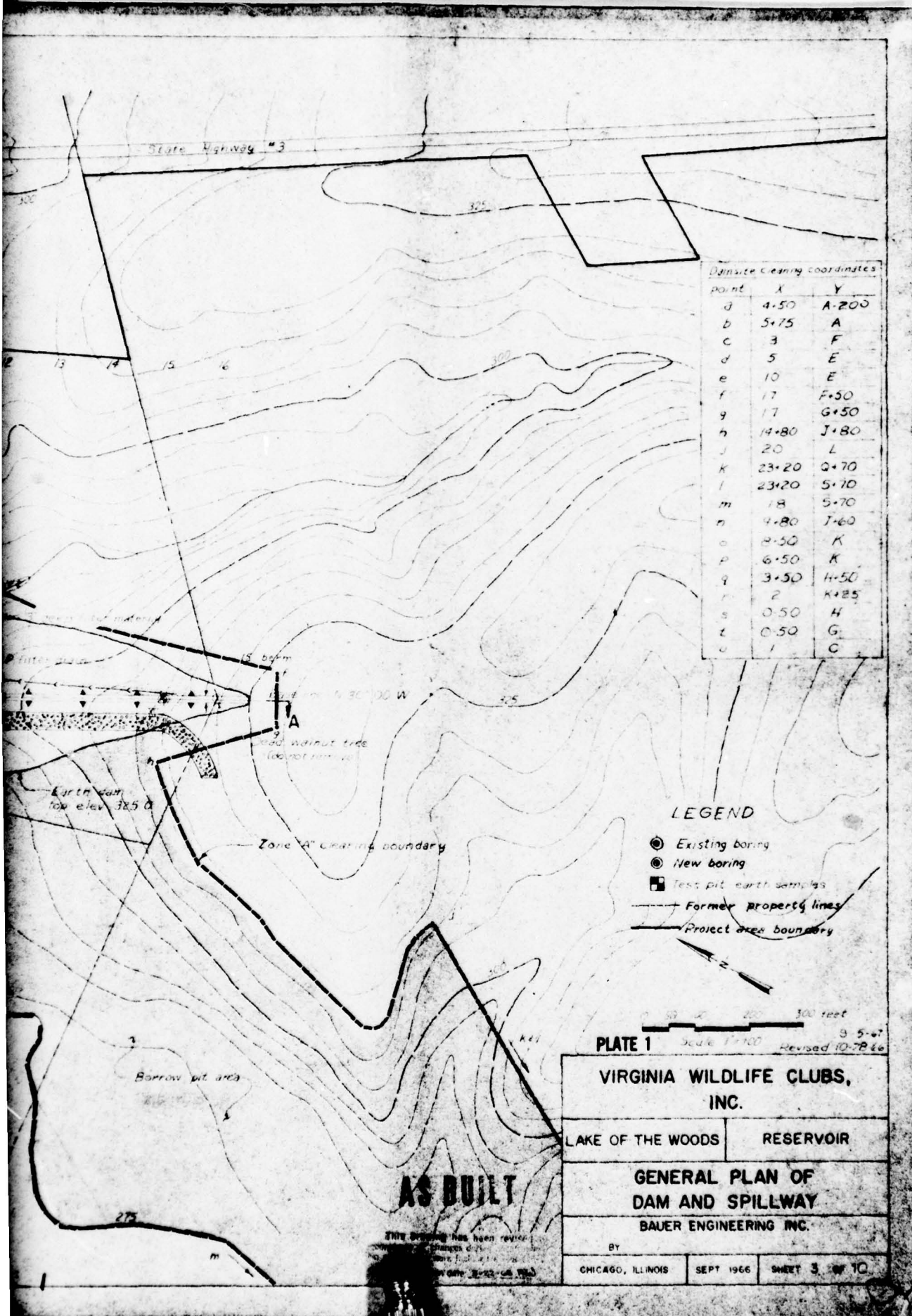
NAME OF DAM: LAKE OF THE WOODS

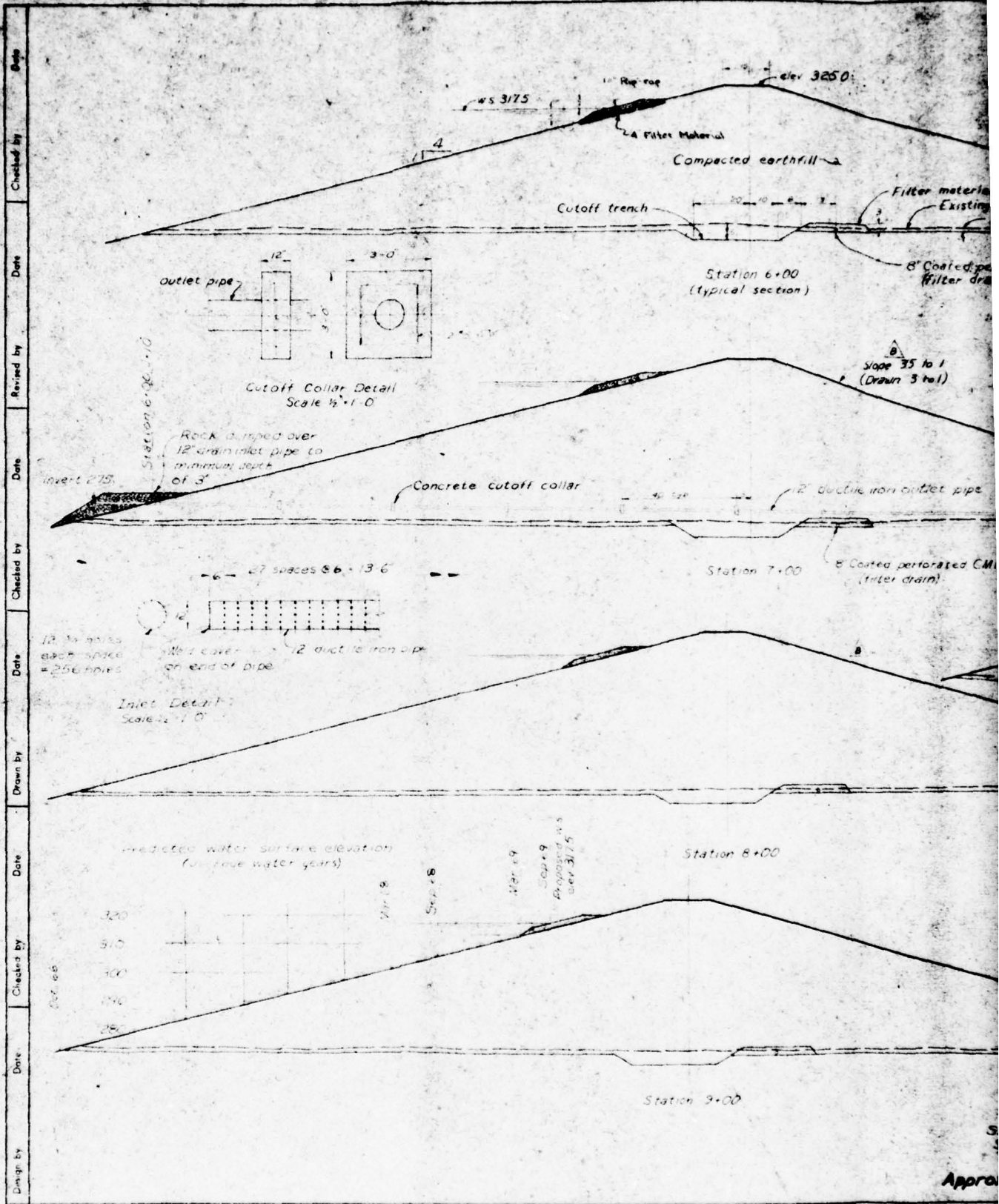


LOCATION PLAN
LAKE OF THE WOODS DAM

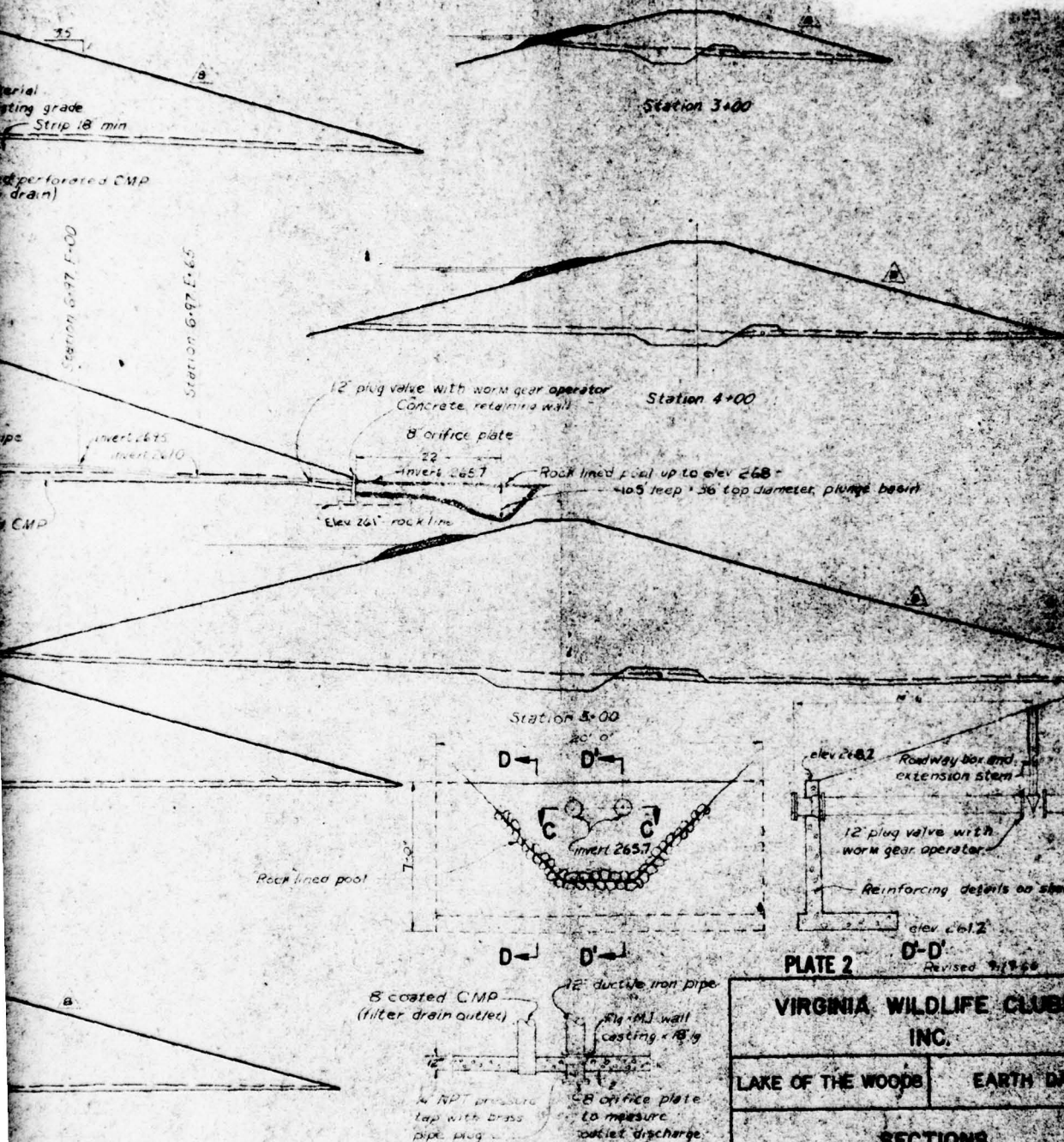


Based on topographic map by
Price William Engineering Co.
Woodbridge, Virginia





Appro



SECTIONS
Scale 1" = 20'
Box Half Scale

AS BUILT

PLATE 2
VIRGINIA WILDLIFE CLUBS, INC.

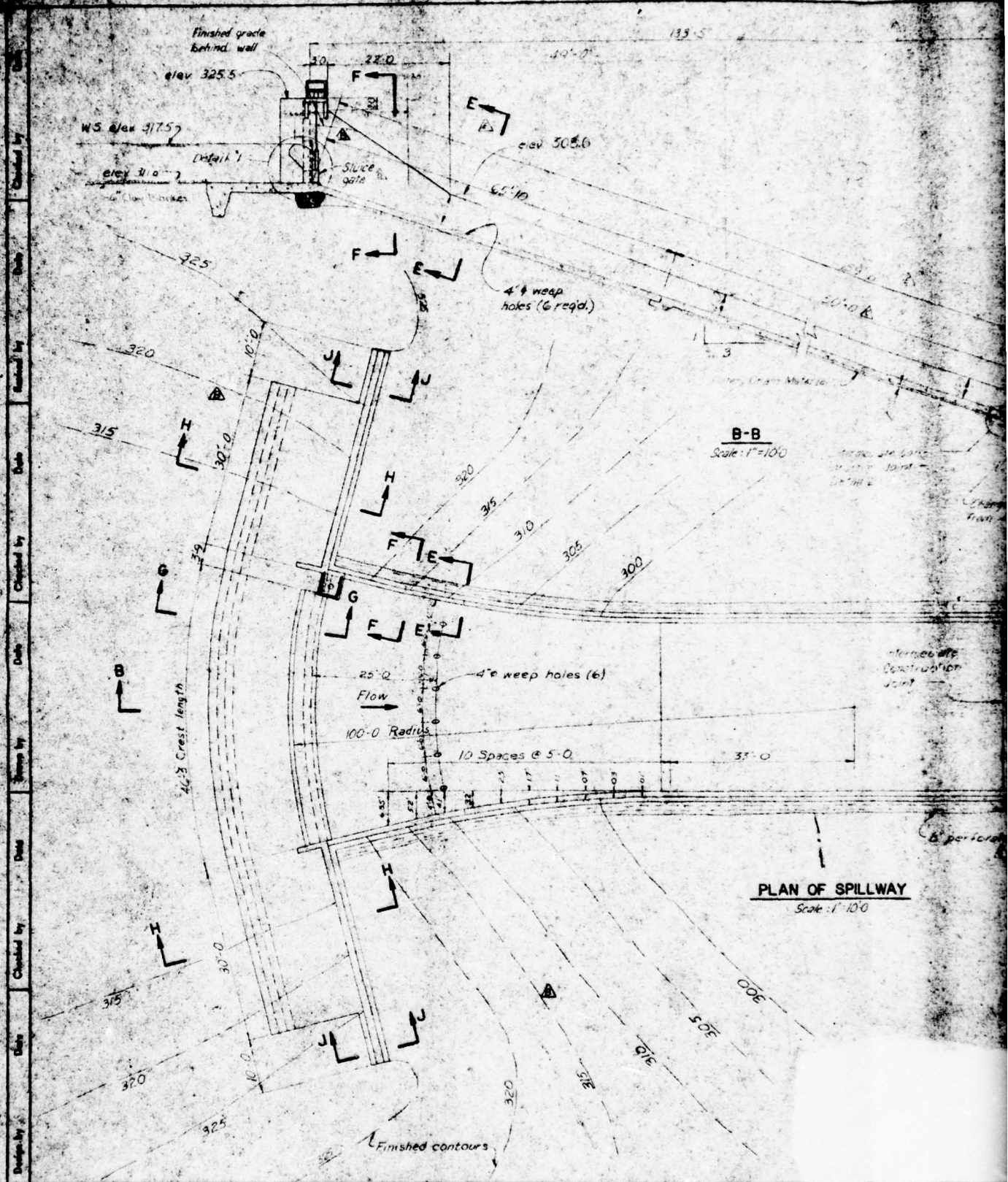
LAKE OF THE WOODS **EARTH DAM**

SECTIONS

BAUER ENGINEERING, INC.

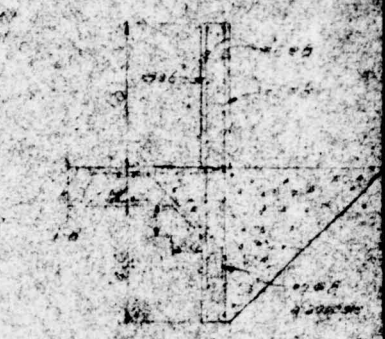
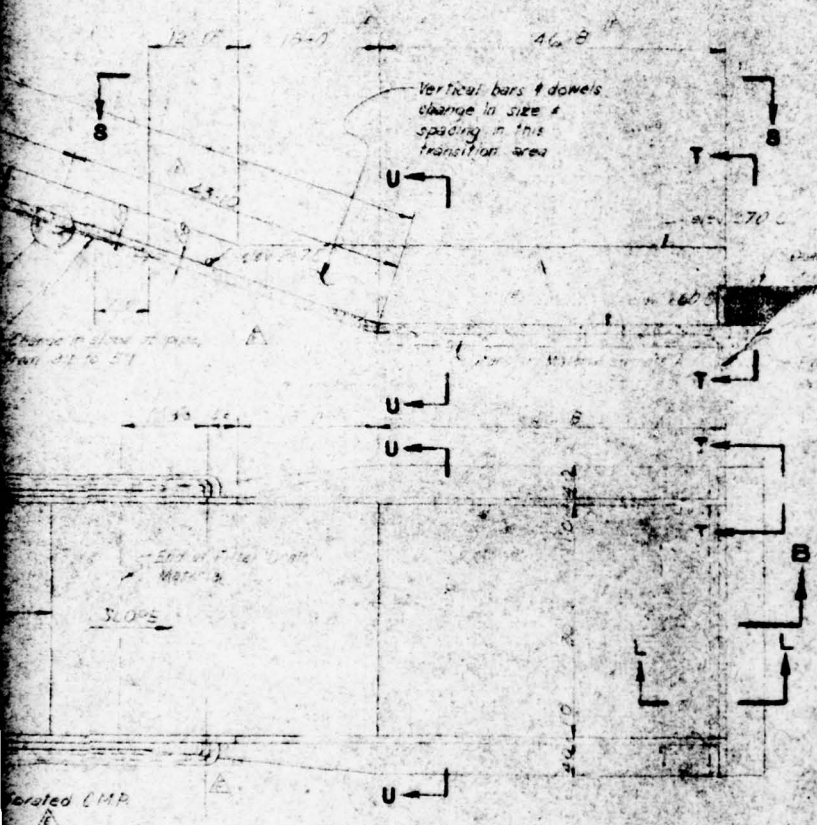
BY CHICAGO, ILLINOIS SEPT. 1968 5-SEP 8 1968

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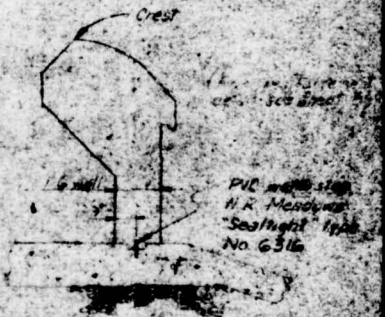


1. Concrete Reinforcing Steel Institute - The Construction of concrete and steel reinforcement is the subject of this publication for the purpose of providing a guide to the proper use of these materials in the construction of concrete structures.

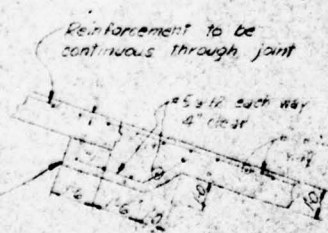
2. Concrete Reinforcing Steel Institute - The Construction of concrete and steel reinforcement is the subject of this publication for the purpose of providing a guide to the proper use of these materials in the construction of concrete structures.



L-L
 Section taken on structure shown in plan view to be constructed by the Engineer.
 When the bridge is to be constructed on a grade, the bridge shall be constructed to a maximum height of 10 feet above the existing ground level.
 The bridge shall be constructed to a maximum height of 10 feet above the existing ground level.



DETAIL 1
 Scale: 3/4" = 1'-0"



DETAIL 2
 Scale: 3/4" = 1'-0"

NOTE
 Spalling slab shall be placed:
 (1) As one continuous placement
 OR
 (2) With not more than two intermediate construction joints

This drawing has been revised to incorporate all changes during construction to subsequent work included within noted. BUILT between date 5-27-66 and 6-1-66

Approx. Half Scale

AS BUILT

PLATE 3

| VIRGINIA WILDLIFE CLUBS, INC. | |
|-------------------------------|-------------------|
| LAKE OF THE WOODS | SPILLWAY |
| PLAN AND SECTIONS | |
| BAUER ENGINEERING INC. | |
| BY | CHICAGO, ILLINOIS |
| CHICAGO, ILLINOIS | CHICAGO, ILLINOIS |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|
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|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|

APPENDIX II

PHOTOGRAPHS

CONTENTS

- Photo 1: Head Wall Containing Filter Drainpipe (Left Side of Photo) and Reservoir Drainpipe (Right Side of Photo)
- Photo 2: Discharge Channel for Concrete Spillway
- Photo 3: Riprapped Approach Channel, Concrete Overflow Weir, Lift Pedestal and Slide Gate
- Photo 4: Slide Gate on Downstream Face of Weir
- Photo 5: Spillway, Stilling Pool, and Downstream Channel
- Photo 6: Large, Wet Area on Left Abutment to Right of Spillway

Note: Photographs were taken on 29 November 1978.

NAME OF DAM: LAKE OF THE WOODS

LAKE OF THE WOODS DAM

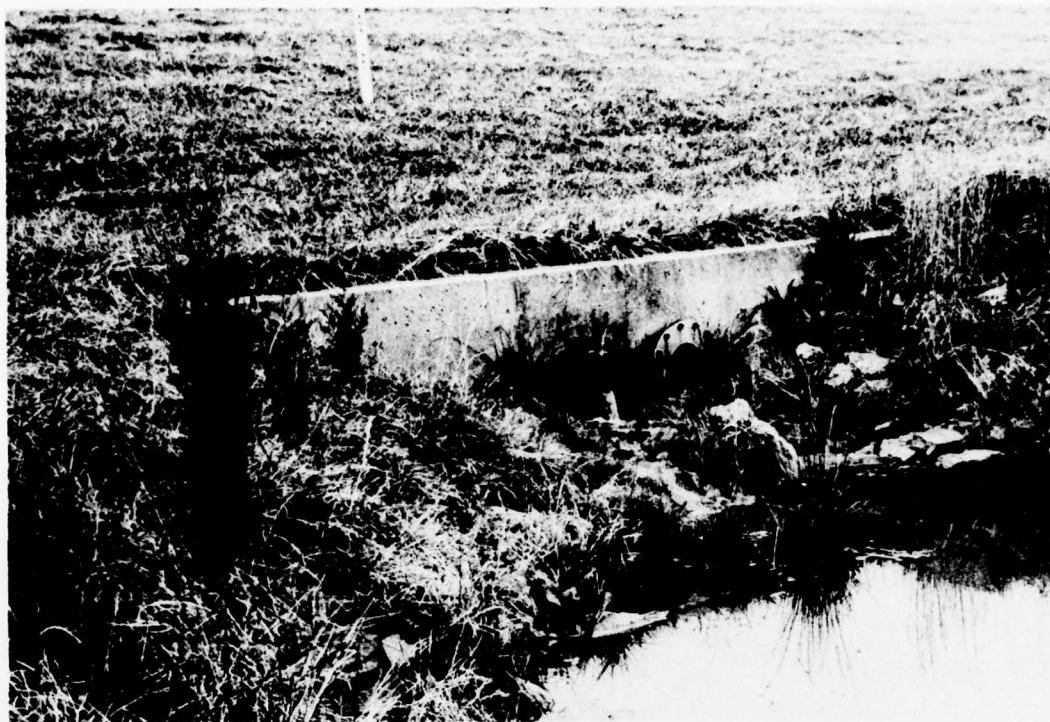


PHOTO 1. Head Wall Containing Filter Drainpipe (Left Side of Photo) and Reservoir Drainpipe (Right Side of Photo)



PHOTO 2. Discharge Channel for Concrete Spillway

LAKE OF THE WOODS DAM

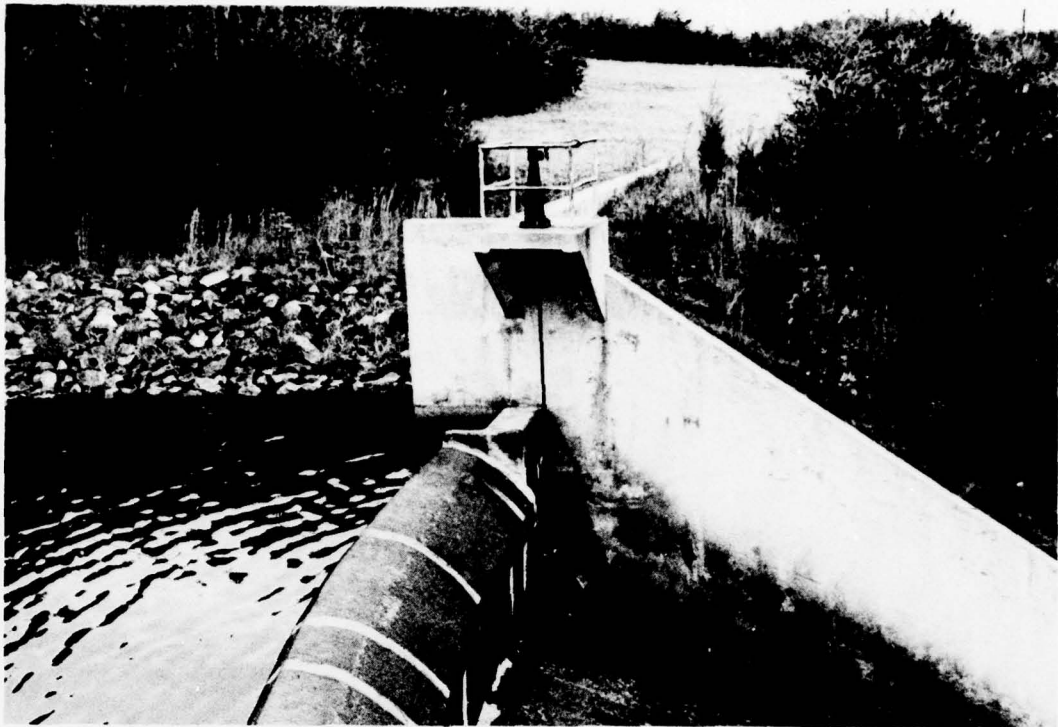


PHOTO 3. Riprapped Approach Channel, Concrete Overflow Weir, Lift Pedestal and Slide Gate



PHOTO 4. Slide Gate on Downstream Face of Weir.

LAKE OF THE WOODS DAM



PHOTO 5. Spillway, Stilling Pool and Downstream Channel



PHOTO 6. Large, Wet Area on Left Abutment to Right of Spillway

APPENDIX III

CHECK LIST - VISUAL INSPECTION

Check List
Visual Inspection
Phase 1

Name of Dam Lake of the Woods County Orange State Virginia Coordinates Lat. 3821.0
Long. 7745.3

Date Inspection 29 November 1978 Weather Rainy, Cloudy Temperature 50°F.

Pool Elevation at Time of Inspection 317.0 ft. M.S.L. Tailwater at Time of Inspection 262.0 ft. M.S.L.

HH-1

Inspection Personnel:
Virginia Water Control Board:

Roy Murphy
Tim Perry

Michael Baker, Jr., Inc.:

T. W. Smith
W. L. Sheaffer
T. J. Dougan

Owner's Representatives:

Arthur Warren
Dean Morley

T. W. Smith Recorder

EMBANKMENT

Name of Dam: LAKE OF THE WOODS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|--|--|--|
| SURFACE CRACKS | No surface cracks were observed. | |
| UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE | There was no movement or cracking observed. | |
| SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES | No sloughing or erosion of the embankment and abutment slopes was observed. | |
| VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST | Good | |
| RIPRAP FAILURES | The riprap on the upstream slope at normal pool elevation and on the approach channel slopes for the emergency spillway is functioning properly. A few small areas have been partially removed and placed in piles. Grass is growing among the stones in some areas. There is scattered driftwood. | The debris should be removed, and the riprap should be replaced. |

EMBANKMENT

Name of Dam: LAKE OF THE WOODS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|-----------------------------------|---|----------------------------------|
| FOUNDATION | <p>The foundation consists of 3 ft. of alluvial, silty sand and gravel in the bottom of the stream valley with 5 to 8 ft. of sandy silt overlying highly weathered gneiss at higher elevations. On the slopes of the valley, 5 ft. of reddish-brown, clayey silt and silty clay cover brown and gray, sandy silt (decomposed rock) which extends to a maximum depth of 50 ft. The underlying bedrock is a highly weathered, brown and gray gneiss. The subsurface data was obtained from the Report of Soils Exploration prepared by Dames and Moore. The cutoff trench is shown to be 30 ft. wide x 5 ft. deep on the as-built cross-sections.</p> | The bare areas should be seeded. |
| CONSTRUCTION MATERIALS AND SLOPES | <p>The as-built typical sections and reports indicate that the compacted earthfill was unzoned and homogeneous with an appreciable quantity of silt. The soil observed on the surface consisted primarily of red, clayey silt with traces of rock fragments. Sandy silt and sand, and gravel were present in a few areas. The slopes (4:1 upstream and 3.5:1 downstream) were well-covered with grass, except for a few small bare areas which are primarily in the path on the crest and where some trees had been removed on the downstream slope. The compaction requirement was reduced from 95% to 88% of modified density.</p> | |

EMBANKMENT

Name of Dam: LAKE OF THE WOODS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|--|--|
| JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM | <p>The abutments are composed of reddish-brown, clayey silt (5 ft. average depth) overlying brown and gray, sandy silt with rock fragments (decomposed rock) to a maximum depth of 50 ft. The top of the bedrock is highly weathered gneiss. The slope gutters are unpaved and covered with grass. The left abutment slope is moderate with grass cover. A clubhouse is located nearby. There are pine trees with soil erosion on the hill near the approach channel on the left side.</p> | <p>The clear seepage and filter drainage do not appear to be excessive.</p> |
| ANY NOTICEABLE SEEPAGE | <p>Clear seepage was observed beside the ditch at the downstream toe in several areas apparently from the filter drain outlets. There is a seepage area (20 ft. diameter) extending 6 ft. up from the toe of the dam in the vicinity of the right abutment. The clear seepage may be caused by a partially blocked outlet from the filter drain or groundwater from the knoll at the abutment.</p> | <p>The clear seepage and filter drainage do not appear to be excessive.</p> |
| STAFF GAGE AND RECORDER | <p>Water levels of 0.5 ft. are painted on the right spillway wall, immediately upstream of concrete weir.</p> | <p>Install a staff gage to monitor reservoir levels above normal pool.</p> |
| DRAINS | <p>Plans show an 8 in. coated perforated filter drain extending along the length of dam from abutment to abutment with an 8 in. coated C.M.P. filter drain outletting alongside to the reservoir drainpipe. The 6 in. C.M.P. had 12 g.p.m. of clear flow indicating that the filter is functioning. The plans also show 6 sections of filter material extending from the 8 in. perforated filter drain and outletting at the toe of dam. These outlets appear to be covered by topsoil and grass. A gravel drain with a plastic cover was found at the ditch approximately 265 ft. to the right of the outlet pipe. The drainage ditch which collects the (continued on next page)</p> | <p>The ends of the filter material extending to the toe should be located and exposed. Also, the drainage ditch along the toe should be kept clear of debris and growth to allow normal drainage from the filter drains.</p> |

EMBANKMENT

Name of Dam: LAKE OF THE WOODS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|-----------------------|---|----------------------------|
| DRAINS (continued) | water from the outlets of the filter drain empties into the stilling basin at the rate of 4 g.p.m. The slopes of the ditch are vegetated with some small trees. The clay and silt slopes are partially eroded at the filter outlets. The ditch near the right abutment area has clear seepage and is blocked with dumped boulders with tree stumps and wood at its upper end. | |

OUTLET WORKS

Name of Dam: LAKE OF THE WOODS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|--|--|---|
| CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT | No severe or unusual cracking and spalling of the head wall at the outlet was observed. | |
| INTAKE STRUCTURE | Intake end of drainpipe was submerged by the reservoir. No observation was possible. | |
| OUTLET STRUCTURE | Consists of a concrete retaining wall with the 8 in. C.M.P. filter drain outlet and the 12 in. ductile iron outlet pipe. The drain had a clear flow of 12 g.p.m. into the stilling basin. The outlet pipe is controlled by a 12 in. plug valve located 15 ft. from the outlet in a roadway box. There is no flow from the outlet pipe. The outlet structure and stilling basin are shown in Photo 1. | |
| OUTLET CHANNEL | The outlet channel flows away from the toe of the dam and joins the spillway channel beyond the left abutment. The stilling basin is lined with riprap. A drainage ditch at the toe of the dam flows into the stilling basin. A stream parallel to the ditch flows into the outlet channel downstream. | |
| EMERGENCY GATE | The reservoir can be lowered by either of two drains: | <ol style="list-style-type: none"> 1) The 12 in. reservoir drain could be used to completely drain the reservoir. 2) The 2-ft.-square sluice gate located on the face of the spillway weir can be used to drain the reservoir to an elevation of 310.5 ft. M.S.L. |

UNGATED SPILLWAY

Name of Dam: LAKE OF THE WOODS

| VISUAL EXAMINATION OF | | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|-----------------------|--|---|---|
| CONCRETE WEIR | | The concrete weir of the spillway crest was laid out on a 100-ft. radius and is 46 ft. long. The weir elevation is 317.5 ft. M.S.L. The weir has been patched with epoxy in 9 places; 2 of the patches are leaking. Small aggregate popouts are present in the crest of the ogee weir (see photos 3 and 4). | |
| APPROACH CHANNEL | | The approach channel to the concrete spillway is approximately 50 ft. wide with the side slopes protected by riprap to 5 ft. above normal water level. Sedimentation is minor because the 2-ft.-square sluice gate on the face of the concrete weir is opened yearly to discharge sediment that has built up (see Photo 3). | |
| DISCHARGE CHANNEL | | The discharge channel has a 3:1 slope and exits into the stilling basin 150 ft. downstream from the weir. The granular filter drain under the spillway chute outlets through 2 pipes into the stilling basin. The discharge channel has expansion-contraction cracks (photo 5) at approximate 25 ft. intervals. Aggregate popouts are present. There is settlement (up to 2 ft. deep) in the soil backfill behind the right wall in the lower portion with erosion at the end and settlement at the end on the left side. A seepage-erosion area of the end of the right wall is shown in photo 6. | The settlement depressions next to both walls should be back filled, compacted, and seeded. Rock riprap placed at the end of the right wall will prevent erosion in the seepage area. |
| BRIDGE AND PIERS | | | None |
| SLIDE GATE | | The slide gate itself is in good condition. Some leakage in the stem of the weir section is present adjacent to the slide gate. The epoxy patchwork has lost its bonding ability and is separating from the concrete. | |

INSTRUMENTATION

Name of Dam: LAKE OF THE WOODS

| <u>VISUAL EXAMINATION</u> | <u>OBSERVATIONS</u> | <u>REMARKS OR RECOMMENDATIONS</u> |
|---------------------------|---------------------|-----------------------------------|
| MONUMENTATION/SURVEYS | None observed | |
| OBSERVATION WELLS | None | |
| WELLS | None | |
| PIEZOMETERS | None | |
| OTHER | | |

RESERVOIR

Name of the Dam: LAKE OF THE WOODS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|-----------------------|---|----------------------------|
| SLOPES | <p>The slopes are gentle to steep and partially wooded. The area has some recreational facilities. There has been erosion in the steep weathered bedrock slopes for the marina and the soil slopes in some of the tributaries which had been noted in the inspection report by E. D'Appolonia in 1969. An increase in the erosion could affect the access roadway.</p> | |
| SEDIMENTATION | <p>Very minor sedimentation is located immediately upstream at the concrete weir along the right wall.</p> | |
| GOLD MINE | <p>The shaft of an old gold mine in the reservoir near the approach channel of the emergency spillway was filled with 10 c.y. of concrete and a reinforced concrete cap was placed at the entrance as shown on the as-built drawings (see Plate 1). No details concerning the extent of the mine are known. The maximum dimensions of the shaft are 8 ft. x 14 ft. x unknown depth.</p> | |

DOWNSTREAM CHANNEL

Name of Dam: LAKE OF THE WOODS

| VISUAL EXAMINATION OF | OBSERVATIONS | REMARKS OR RECOMMENDATIONS |
|---|--|----------------------------|
| CONDITION (OBSTRUCTIONS, DEBRIS, ETC.) | The channel is lined with riprap for a short distance downstream of the stilling basin and is generally free of obstructions and debris. Photos 5 and 6 show the downstream channel and a seepage area on the right side at the end of the spillway. | |
| SLOPES | The slopes are varied with some clear seeps and small springs. The springs are principally near the base of the left hillside, 300 ft. past the end of the concrete spillway. There is a steeply dipping exposure of weathered metamorphic bedrock (uncertain age) with igneous intrusions at approximately 400 ft. downstream where reeds have grown. A clear seep in the right bank has caused erosion in the clay, silt, and sand 500 ft. downstream. Soft bedrock is in the streambed. | |
| APPROXIMATE NO. OF HOMES AND POPULATION | A treatment plant for the development is located 500 ft. downstream of the dam. A new development is planned directly downstream of the dam. | |

APPENDIX IV

CHECK LIST - ENGINEERING DATA

**CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION**

Name of Dam: LAKE OF THE WOODS

| <u>ITEM</u> | <u>REMARKS</u> |
|--------------------|---|
| PLAN OF DAM | A complete set of as-built drawings are available from the owner. A plan view of the dam is included in this report as Plate 1. |

REGIONAL VICINITY MAP is included in report as Location Plan.

CONSTRUCTION HISTORY The foundation investigation was done in 1966 by Dames and Moore. The dam was designed by Bauer Engineering, Inc. (Chicago, Illinois) in 1966 and constructed by Shoosmith Bros., Inc. in 1967 and 1968.

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TYPICAL SECTIONS OF DAM Typical section of the dam is enclosed in the Phase I Inspection Report as Plate 2.

HYDROLOGIC/HYDRAULIC DATA Partial hydrologic and hydraulic design data is available from the owner.

OUTLETS - PLAN,

DETAILS,

CONSTRAINTS,

and

- **DISCHARGE RATINGS** are available from the owner.

RAINFALL/RESERVOIR RECORDS Rainfall and reservoir level records are available from the owner.

Name of Dam: LAKE OF THE WOODS

| <u>ITEM</u> | <u>REMARKS</u> |
|---|---|
| DESIGN REPORTS | Design reports, calculations, and specifications as prepared by Bauer Engineering, Inc. are available from the owner. |
| GEOLOGY REPORTS | A subsurface investigation consisting of test pits and test borings are part of the design documents. A report of soils investigation is available and enclosed in Appendix VI. |
| DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES | Dam stability analyses and seepage studies were available. Stability analyses are enclosed in Appendix VII. |
| MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD | Materials investigations, boring records, laboratory test results, and field data were available. |
| POST-CONSTRUCTION SURVEYS OF DAM | Several inspections and reports were made between 1969 and 1972 by engineering firms (Appendix V). Remedial recommendations were prepared. |
| BORROW SOURCES | The borrow pit was located on the hillside upstream from the right abutment in the reservoir area as shown on the General Plan of the as-built drawings (Plate 1). |

Name of Dam: LAKE OF THE WOODS

| ITEM | REMARKS |
|------|---------|
|------|---------|

| | |
|--------------------|---|
| MONITORING SYSTEMS | No monitoring system was designed into the dam. |
|--------------------|---|

MODIFICATIONS Some relatively minor modifications which included surface maintenance were recommended after the inspections (Appendix V). It is not known whether all of them were carried out.

HIGH POOL RECORDS No high water records were available.

POST-CONSTRUCTION ENGINEERING Post-construction engineering studies and inspection reports were available
STUDIES AND REPORTS (Appendix V).

PRIOR ACCIDENTS OR FAILURE OF DAM None
DESCRIPTION
REPORTS

MAINTENANCE Recent inspection reports were not available.
OPERATION
RECORDS

Name of Dam: LAKE OF THE WOODS

| <u>ITEM</u> | <u>REMARKS</u> |
|-------------|----------------|
|-------------|----------------|

SPILLWAY PLAN,

SECTIONS
and
DETAILS

Sections and details of the ungated concrete spillway are enclosed as Plate 3.

OPERATING EQUIPMENT
PLANS & DETAILS

are contained in the as-built drawings.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 7.23 sq.mi.

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 317.5 ft. M.S.L.
(9880 ac.-ft.)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 325 ft. M.S.L.
(14,160 ac.-ft.)

ELEVATION MAXIMUM DESIGN POOL: 324.2 ft. M.S.L.

ELEVATION TOP DAM: 325.0 ft. M.S.L.

CREST: Principal Spillway

- a. Elevation 317.5 ft. M.S.L.
- b. Type Overflow type concrete spillway
- c. Width 46 ft. crest width
- d. Length Approximately 210 ft.
- e. Location Spillover Outside left abutment
- f. Number and Type of Gates 1 slide gate (2-ft.-sq.) on left side
of weir (elev. 310.5 ft. M.S.L.)

OUTLET WORKS: Reservoir Drain

- a. Type 12-in. diameter ductile iron pipe
- b. Location Exits at toe of dam near center of embankment
- c. Entrance inverts 275.0 ft. M.S.L.
- d. Exit inverts 265.7 ft. M.S.L.
- e. Emergency draindown facilities 2 x 2 ft. sluice gated outlet and
12 in. dia. blow-off pipe

HYDROMETEOROLOGICAL GAGES: None at dam site

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE Unknown

Name of Dam: LAKE OF THE WOODS

APPENDIX V

INSPECTION REPORTS

BAUER ENGINEERING INC
CONSULTING ENGINEERS ENGINEERING HYDRAULICS
20 NORTH WACKER DRIVE
CHICAGO, ILLINOIS 60606

TELEPHONE
FRANKLIN 2-8800

TELETYPE
BAUEREN 2-CHIL300

PROGRESS REPORT NO. 2

Lake of the Woods -- Dam Construction

As of April 21, 1967

After being closed for the winter months, construction on the main dam resumed April 12, 1967. Although the work proceeded slowly during the first week progress was steady.

Attaining the 95% (Modified AASHO) requirement remains a serious problem. Great effort is required by the contractor to dry and roll the variable soil encountered.

The compaction results indicate the following (as of 4/21/67):

| | |
|---|----------------|
| Total tests taken ----- | 10 |
| Range of test results ----- | 84% to 101% |
| Number of tests passing ----- | 3 |
| Number of tests failing ----- | 7 |
| Number of failing tests improved after rerolling ----- | 3 |
| Moisture content range ----- | 18.3% to 26.6% |
| Average field moisture content ----- | 23.4% |
| Average optimum moisture ----- | 21.3% |

With a concerted effort, the required densities on the average can be obtained.

The filter drain material was delivered and checked for gradation. The gradation indicates the material falls within the requirements and was approved.

The cutoff trench had been partially backfilled December, 1966 and through the winter months was saturated with water. This material was removed to the rock layer beneath and backfilled with selected soil.

Tests indicate 100% compaction achieved.

The temporary dam was completed during the winter and appears to be operating very well. Water has been impounded to the overflow elevation and the overflow pipe is operating as expected. No adverse effects were observed.

SUMMARY

Progress on the main dam is proceeding slowly. Complying with compaction requirements remains a problem. The Contractor will have to take extra care to insure the material being rolled has a low enough moisture content to achieve specified compaction, thus assuring a satisfactory end result.


Donald W. Wikan

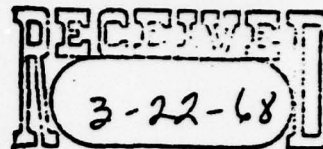
DWW:fb

BAUER ENGINEERING, INC.
CONSULTING ENGINEERS-ENGINEERING HYDRAULICS
20 NORTH WACKER DRIVE
CHICAGO, ILLINOIS 60606

TELEPHONE
FRANKLIN 2-6666

March 21, 1968

CABLE ADDRESS
"BAUERENG CHICAGO"



Mr. Wesley T. Butler
Virginia Wildlife Clubs, Inc.
United States Land, Inc.
P.O. Box 631
Springfield, Virginia 22150

J. KEATING

~~J. FORD~~

KA

Subject: Lake-of-the-Woods

Dear Mr. Butler:

On March 6, 1968 a final inspection of the dam, spillway and appurtenement work was made by me and Earl Turner, our engineer - inspector for the above project. We were accompanied by Mr. Jack Schaul of your organization and Mr. Bill Cantrell of Shoosmith Brothers.

We are pleased to report that the construction work is substantially completed in accordance with the plans and specifications except the fine grading, seeding and fertilizing in the spillway area beyond the chute and stilling basin walls, and in the vicinity of the plunge pool. This work should be completed soon after the backfill adjacent to the chute walls has subsided and been re-graded, and the weather permits.

We are preparing a set of as-built drawings and a tabulation of final quantities for the project, and hope to have this information in your hands in about a week.

Mr. Wesley T. Butler...Mar. 21, 1968...RLH...2

The dam and spillway present an excellent appearance, and we believe that both United States Land and Shoosmith Brothers can be proud of the fine results.

It has been a pleasure for our firm to be associated with you on this project, and we send our best wishes for your continued success.

Very truly yours,


R. L. Hall
Chief Engineer

RLH:db

cc: Mr. J. S. Keating
Mr. Jack Ford ✓
Mr. Jack Schaul
Mr. Gay Jones
Shoosmith Bros., Inc.

Project No. 69-181

BOISE CASCADE PROPERTIES, INC.
CHICAGO, ILLINOIS

LETTER REPORT
INSPECTION OF DAM AND RESERVOIR
LAKE OF THE WOODS
ORANGE COUNTY, VIRGINIA

E. D'APPOLONIA
CONSULTING ENGINEERS, INC.
PITTSBURGH, PENNSYLVANIA

OCTOBER 1969

V-5

E. D'APPOLONIA
CONSULTING ENGINEERS, INC.

October 27, 1969

15 DUFF ROAD
PITTSBURGH, PA. 15235

TELEPHONE
(412) 242-5107

Project No. 69-181

Mr. John Margosian
Boise Cascade Properties, Inc.
Lake of the Woods
P. O. Box 128
Springfield, Virginia 22401

Inspection of Dam and Reservoir
Lake of the Woods
Orange County, Virginia

Dear Mr. Margosian:

Enclosed are two copies of our letter report discussing the results of our inspection of the dam and reservoir at the Lake of the Woods project. We were initially requested to review the performance of the reservoir with respect to filling. However, as I have indicated in telephone conversations, certain other conditions at the site deserve discussion. Therefore, in addition to the section on filling, our letter report discusses other adverse conditions along with recommendations concerning remedial and preventive measures.

As requested, we are preparing a single invoice reflecting all of our costs on this project. The two previous, partial invoices should be ignored when the total invoice is submitted. I will include a description of the various cost items for your information.

Please feel free to call pertaining to any of the subjects discussed in the report.

Very truly yours,

Richard D. Ellison

Richard D. Ellison

RDE:pao

Enclosures

cc: Mr. J. W. Ford (2)

V-6

E. D'APPOLONIA
CONSULTING ENGINEERS, INC.

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Letter Report

Appendix A

Drawings (in folders)

E. D'APPOLONIA

CONSULTING ENGINEERS, INC.

October 25, 1969

15 DUFF ROAD
PITTSBURGH, PA. 15235

TELEPHONE
(412) 242-8107

Project No. 69-181

Mr. John Margosian
Boise Cascade Properties, Inc.
Lake of the Woods
P. O. Box 128
Springfield, Virginia 22401

Letter Report
Inspection of Dam and Reservoir
Lake of the Woods
Orange County, Virginia

Dear Mr. Margosian:

Pursuant to Mr. J. W. Ford's authorization in June, 1969, we conducted a visual inspection of the dam and reservoir at the subject site. Pertinent design and as-built drawings prepared by Bauer Engineering Company were also examined. Initially, the purpose of the examination was to assess the behavior of the dam and reservoir to date with respect to its filling rate and to make appropriate comments and observations. However, during the above examination and as subsequently discussed with Mr. Ford, additional conditions related to the condition of the dam and reservoir were noticed for which recommendations concerning remedial and preventive measures are also reported herein.

Description of Dam

The dam has a maximum height of almost 60 feet above the bed of Flat Run. It is of homogenous section except for the drainage system beneath the downstream portion of the embankment. The material in the dam was borrowed from the reservoir area immediately upstream of the dam. Examination of soils in the area indicates that this material contains an appreciable quantity of silt-sized particles and that its permeability when compacted is relatively low.

The downstream sub-embankment drainage system consists of a lateral filter, parallel to the dam axis, with embedded pipe draining from both sides towards the old bed of Flat Run. The system then runs along the creek bed and discharges at the toe of the dam. There is no indication that it is not functioning properly.

E. D'APPOLONIA

CONSULTING ENGINEERS, INC.

Mr. John Margosian

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October 25, 1969

The lateral drain, which is located immediately downstream of the axis of the dam, is augmented by "fingers" of filter material running transverse to the axis of the dam and presumably draining towards the toe. The downstream ends of these drains have apparently been covered with topsoil.

The performance of these finger drains is not known. A narrow strip of wet soil, as discussed below, exists just downstream of the toe of the dam. This would seem to indicate that at least some of the drains are functioning properly. However, as will be discussed, this wet zone could have a different origin.

Two important changes were made to the embankment design during construction of the dam. First, impervious blankets were provided in two parts of the borrow areas. They were apparently in response to the porous nature of the bedrock. Second, the 3:1 design slopes were changed to 3.5:1 downstream and 4:1 upstream. The reasons for the slope changes are not known.

Another change made during construction was to provide a continuous filter system under the spillway chute. The water collected in this filter discharges through two pipes into the stilling basin. The pipes are presently discharging water which would indicate that the drainage system under the chute is operating.

The as-built drawings show an abandoned mine shaft just upstream of the the spillway channel. The shaft is presently under water. No details concerning the extent of the mine are available.

A 6-inch pipe has been installed through the embankment adjacent to the right abutment. The pipe is close to the crest of the dam and serves no apparent purpose.

Performance of the Dam

The reservoir is presently being filled for the first time, and two seepage zones have appeared downstream of the dam. The approximate extent of the seepage zones as of August 17, 1969 is sketched in Drawing No. 69-181-E1. At that time, the reservoir was 4.75 feet below design elevation. (We understand that the lake level rose an additional 1.0 to 1.5 feet during the heavy rains associated with Hurricane Camille during the week of August 17, 1969) No correlation between the height of the reservoir and the seepage phenomena is available.

One seepage zone, (A)*, is entirely in cut downstream of the spillway stilling basin. Because of the proximity of the drainage blanket under the spillway chute, it would appear that the seepage zone may be fed from deeper within the underlying rock.

*Letters designated as () correspond to similarly designated areas on Dwg. 69-181-E1.

E. D'APPOLONIA

CONSULTING ENGINEERS, INC.

Mr. John Margosian

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October 25, 1969

The other seepage zone, (B), is in undisturbed ground downstream of the right abutment. This zone has extended into the dam embankment along a distance of approximately 100 feet. The maximum intrusion up the embankment is about 8 feet measured vertically.

A portion of Seepage Zone (B) is located over one of the finger drains described above. The downstream end of the drain was not located in the field because it apparently was covered during dressing of the slope. If the finger drain were functioning properly it would be expected to yield some water flow.

Part of Seepage Zone (B) runs in a narrow strip parallel to the toe of the dam. It may be that this "wet" strip is caused by discharge from the finger drains and not from seepage through the foundation of the dam. The other portion of the seepage zone undoubtedly is affected by seepage from the reservoir through the bedrock since it is directly across the creek bed paralleling the toe of the dam. It is difficult to judge whether the source of this seepage is primarily from groundwater flow out of the knoll to the west or if it is primarily due to increased groundwater pressure resulting from the partially filled reservoir. Records of the preconstruction condition of this area would be valuable in determining the source of this seepage.

Several surface erosional features have appeared on and around the dam. Shallow gullies, (C), have developed on the entire lower portion of the downstream slope; along the toe of the dam on the north side of the discharge basin for the under drain discharge pipes (D); and north of and generally parallel to the excavation for the spillway discharge channel, (E).

The water in the reservoir immediately adjacent to the riprap on the upstream slope of the dam is reddish in color. This indicates that a certain amount of erosion is taking place. Since the reservoir at time of observation was 4.75 feet below design elevation, it is not known whether the erosion is taking place below the riprap or through the lower portion of the riprap.

Erosion, due to rainfall runoff, is present at the portion of the spillway approach channel not protected with riprap, (G). Additional erosion should be expected when the water level rises and continual flow occurs through the channel.

Performance of the Reservoir

Filling of the reservoir commenced in 1967. The water level on August 17, 1969 was 4.75 feet below the design elevation. Because the time of filling thus far is still in the range of the estimates made by Bauer Engineering Company (35 months) and E. D'Appolonia Consulting Engineers, Inc. (23 months), conclusions regarding the rate of filling cannot be made at this time. However, it is somewhat disturbing that it has been reported that the reservoir rose only about six inches during July, 1969, while the local rainfall was about twice that amount. The rate of filling should be observed, in

E. D'APPOLONIA

CONSULTING ENGINEERS, INC.

Mr. John Margosian

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October 25, 1969

relation to rainfall, through the spring of 1970 prior to evaluating the time which will be required to fill the remainder of the lake.

An analysis of the flow into the reservoir was conducted on August 16 and 17, 1969. The flow into the lake was measured at each stream entering the lake at the locations shown on Dwg. 69-181-E2. The total inflow at the time of measuring was about 1.5 gallon per second. The total surface flow out of the reservoir was determined by measuring the flow in the discharge channel downstream from the dam. This flow was corrected to account for flow in the 36 inch diameter culvert located downstream from the south abutment as shown on Dwg. 69-181-E2. This analysis indicated that the reservoir on that date was filling at the rate of about 0.2 gallons per second; neglecting sub-surface inflow and outflow which cannot be measured. (Details of the analysis are presented in Appendix A). This amount of inflow would have a negligible effect on the lake level.

It should also be noted that due to the relatively large size of the lake, the measured amount of surface leakage will not seriously effect the lake level once it has filled to the planned normal pool elevation.

Miscellaneous Observations Pertaining to the Reservoir

Two less serious problems associated with the reservoir were observed on August 17, 1969.

First, gullies several feet in depth have been eroded into the steep slopes cut into weathered rock to form the boat marina. The incompetent nature of the weathered rock and the concentrated flows which occur in this area make this a progressive condition.

The second concerns erosion of the surficial soils at many of the tributaries into the lake. In several instances, this erosion has progressed to the point where the stability of the site roadway may be affected.

Recommendations for Remedial and Preventive Measures

1. Dam and Appurtenances

Both seepage zones downstream of the dam can be expected to increase in size and rate of discharge as the reservoir rises to design elevation. The correlation between seepage discharge and reservoir discharge is purely conjectural at this time. However, it is entirely possible that the discharge will increase significantly with the last few feet of head. The present rate of seepage will not significantly affect the lake level once it has reached the design normal pool elevation and should not be sufficient to pose a threat to the overall stability of the dam due to piping. However, it is recommended that size of the seepage zones and the seepage discharge be closely observed so that large changes will be recognized at an early date. Also, that portion

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CONSULTING ENGINEERS, INC.

Mr. John Margosian

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October 25, 1969

of the dam toe included in seepage zone (B) should be inspected regularly for evidence of piping or local shear failure.

As soon as possible the finger drains entering seepage zone (B) should be located and exposed to provide free flow of water from beneath this portion of the embankment. The flow from this finger drain as well as all other seepage from this zone should be collected into a well defined channel (F) and diverted to the old stream bed. This channel should be placed as far from the toe of the dam as possible.

If the condition of the toe of the dam deteriorates to the point where it poses a threat to stability, an inverted filter should be designed and placed over the significant portion of the seepage zone. This can be designed to protect against both piping failure and local shear failure.

It is not anticipated that seepage in the vicinity of the stilling basin will pose any threat to stability in the near future. However, it may be desirable for esthetic purposes and for prevention of problems with freezing behind the wall to provide drainage facilities behind the retaining walls of the stilling basin.

The erosion gullies do not at this time present any threat to the stability of the dam. However, due to the progressive nature of such erosion, it is prudent that preventive measures be taken as soon as possible. A shallow berm with paved gutters or half-round terra-cotta pipe gutters should be constructed about one-third way up the downstream face of the dam to collect runoff from the slope. Also, a lined terra-cotta pipe channel should be provided along the toe of the dam to the north of the discharge basin in the area designated as (D) on Dwg. 69-181-El. The shallow erosion gullies, (C), on the downstream slope should be filled and seeded. Remedial and preventive work on the erosional features to the north of the discharge channel can be postponed indefinitely, but periodic observations should be made for re-evaluation of this condition.

The riprap in the spillway approach channel, (G), should be extended to the concrete structure to prevent further erosion in this area.

It is not possible at this time to determine whether the erosion of the dam at the present water line is taking place through the riprap or at a lower elevation. No remedial work in this area is recommended until the reservoir level is raised and the behavior of the riprap can be observed further. However, if the reservoir is maintained at or near its present level for a considerable period of time, the upstream face of the dam below the riprap should be inspected by one of our engineers trained in scuba diving.

It is not expected that the pipe through the top of the dam, (H), will ever carry water. Nevertheless, it should be removed or permanently sealed.

E. D'APPOLONIA

CONSULTING ENGINEERS, INC.

Mr. John Margosian

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October 25, 1969

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The riprap in the spillway approach channel, (G), should be extended to the concrete structure to prevent further erosion in this area.

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E. D'APPOLONIA
CONSULTING ENGINEERS, INC.

Mr. John Margosian

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October 25, 1969

2. Reservoir filling

While concern over the slow filling rate of the reservoir is well founded, "filling time" calculations indicate that additional time should be allowed before concluding that the lake will not reach its normal pool elevation without expensive remedial or artificial filling measures. A rational decision on whether to implement such plans could be made after correlation of reservoir level, local rainfall data and seepage data this winter and spring (1969 - 1970). The present magnitude of surface seepage will not have a significant effect upon maintaining a relatively constant lake level.

3. Reservoir (Miscellaneous)

Riprap protection should be provided at the road culverts for any tributaries where the erosion may cause costly disturbance to the roadway or culvert. ←

Finally, the cut slopes at the marina should be made flatter and/or a paved gutter should be provided along the top of the slope to retard the progressive erosion which is presently occurring. Also, riprap should be provided at the toe of the slope to eliminate erosion due to wave action which will occur when the lake level has reached its normal pool elevation. ←

Data Required

Additional information which will be required prior to conducting a more detailed study and prior to undertaking the recommended preventive and remedial measures include geologic reports prior to construction, geologic data obtained during construction, engineering properties of embankment material, and details of the mine shaft at the north abutment. Also, plans showing the location of roads and utilities are required for locating these facilities in the construction area.

Respectfully submitted,


Richard D. Ellison

Attachments

RDE:db

APPENDIX A

E. D'APPOLONIA
CONSULTING ENGINEERS, INC.

Lake of the Woods
Summary of Measured Flows
August 16 and 17, 1969

I: Surface inflows (see Dwg. 69-181-E2 for Tributary Locations)

| <u>Tributary Number</u> | <u>Remarks</u> | <u>Measured Flow in gallons/second</u> |
|-----------------------------|---|--|
| 1A | | dry |
| 1B | | dry |
| 1C | Erosion has occurred to a depth of two feet. Some groundwater seepage is noticeable. | 0.10 |
| 1D | Very little flow from flat swamp area. | TSTM* |
| 2 | 30" ϕ culvert with considerable erosion at its outlet. | TSTM |
| 3 | Kaolinite weathered gneiss. | TSTM |
| 4 | 30" ϕ culvert with considerable erosion in weathered rock at the road embankment. | dry. |
| 5A | 18" ϕ culvert. | dry |
| 5B | Kaolinite weathered grey granite - gneiss. | 0.05 |
| 6 | Very weathered schists. | 0.05 |
| 7 | 42" ϕ culvert. | 0.10 |
| 8A | | dry |
| 8B | | dry |
| 9A | | dry |
| 9B | | TSTM |

*TSTM - Too small to measure.

E. D'APPOLONIA
CONSULTING ENGINEERS, INC.

2.

| <u>Tributary Number</u> | <u>Remarks</u> | <u>Measured Flow in gallons/second</u> |
|-----------------------------|--|--|
| 10A | | TSTM |
| 10B | Some erosion has occurred in the weathered rock. | 0.15 |
| 11 | Erosion has occurred to a depth of 4 to 5 feet. | 0.15 |
| 12 | | TSTM |
| 13 | | 0.05 |
| 14 | | 0.50 |
| 15A | | dry |
| 15B | | dry |
| 15C | | dry |
| 15D | | dry |
| 16 | | 0.05 |
| 17 | | TSTM |
| 18 | Erosion has occurred to a depth of 4 feet. | 0.05 |
| 19 | | TSTM |
| 20 | Some ground water seepage noticeable. | TSTM |
| 21 | Erosion has occurred to a depth of 1.5 feet. Some ground water seepage is noticeable. | dry |
| 22 | | dry |
| 23A | Erosion is occurring in the weathered rock Some ground water seepage is noticeable | TSTM |
| 23B | Erosion has occurred to a depth of 3 feet. Some ground water seepage is noticeable. | TSTM |
| 24 | 36" ϕ culvert. | TSTM |

E. D'APPOLONIA
CONSULTING ENGINEERS, INC.

3.

| Tributary Number | Remarks | Measured Flow in gallons/second |
|-----------------------------|---|------------------------------------|
| <u>Tributary Number</u> | <u>Remarks</u> | <u>gallons/second</u> |
| 25 | | dry |
| 26 | Very little erosion | dry |
| 27 | Erosion has occurred to a depth of 2 feet | TSTM |
| 28A | | dry |
| 28B | | dry |

Summary of Inflow

| | |
|----------------------|---------------------------|
| Tributaries 1 to 28B | 1.20 gallon/second |
| + 14 x TSTM | <u>0.30</u> gallon/second |
| Total surface inflow | 1.50 gallon/second |

II: Surface outflow

| | |
|---|----------------------------|
| Flow at the local road downstream at the outflow channel | 1.5 gallon/second |
| Flow through culvert ϕ 36" at south abutment | - <u>0.2</u> gallon/second |
| Total surface outflow | 1.30 gallon/second |

III: Net surface inflow = $1.50 - 1.30 = 0.20$ gallon/second.

RECEIVED

SEP 4 1970

OPERATIONS
EAST

BAUER ENGINEERING, INC.
CONSULTING ENGINEERS LAND AND WATER RESOURCES
20 NORTH WACKER DRIVE
CHICAGO, ILLINOIS 60606

TELEPHONE
(312) 641-0210

August 27, 1970

CABLE ADDRESS
"BAUERENG CHICAGO"

Mr. Dominic DiOrto
Eastern Region Operations Manager
Boise Cascade Corporation
10400 W. Higgins Road
Rosemont, Illinois 60618

Re: Inspection Report Dam at Lake
of the Woods 198.001

Dear Mr. DiOrto:

A thorough inspection of the main dam at Lake of the Woods, Virginia was made August 17, 1970 at your request. In general, the dam appeared to be in excellent condition.

The enclosed check list was used and appropriate comments made.

Please Note the following corrective actions are indicated as being necessary:

1. TOP OF DAM

The top of the dam appears to be irregular and rutted. A profile should be made along the centerline of the dam to determine if the dam is at the designed grade. Since no bench marks may be available, I suggest the elevation of the spillway crest be used as elevation 317.5. The dam then should have an elevation no lower than 325 or 7.5 feet above the spillway crest. If it is found that the elevation of the top of dam is lower than elevation 325 material, either clay or well graded crushed rock, should be added. If clay is used the existing surface should be scarified and the new material rolled with a sheepsfoot in layers not exceeding 8 inches thick.

If the elevation is found to be higher than 325, the top should be scarified and reshaped with a blade in order to obtain a uniform section which will drain (preferably into the lake) and which has no ruts.

2. ABUTMENTS

Generally the abutments are in excellent condition. No seepage was noted where the fill contacts the original ground. However, some erosion was noticed at the downstream slope of the north abutment. The grade is steep and a grass cover from seed will be difficult to grow. Sod is suggested here in order to stop further deterioration.

3. DOWNSTREAM SLOPE

This also appears to be in good condition. No adverse seepage is evident. One filter drain is flowing slowly, but this is normal and will cause no trouble. Some erosion was noticed. The downstream slope should be repaired and seeded such that a good stand of grass checks further erosion. Regular mowing should be done in order to prevent trees from growing.

A wrench should be provided for the outlet valve.

4. DOWNSTREAM FROM TOE

No problems noted.

5. SPILLWAY

Generally the spillway is in excellent condition. Some small hairline cracks were noted. These are simply shrinkage and in no way will impair the performance of the concrete. In time (2 or 3 years) these cracks may become larger. At that time they could require cleaning, widening and filling with a sealant. I suggest using "Sika Colma Joint Sealer - NS" in accordance with Manufacturer's instructions.

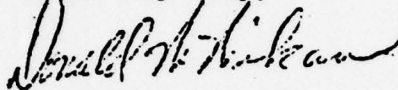
Mr. Dominic DiOrto

Page 3

This dam appears to be in excellent condition and is safe.

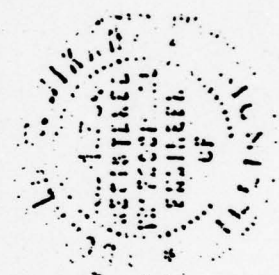
I hope this report serves your needs. If I can be of any more service please let me know.

Yours very truly,



D. W. Wikan P.E.
Chief Engineer

DWW:mb



W. J. Bauer
President

CAUER
ENGINEERING,
INC.

Job No. 128,001 Date 8/17/70

Job Name Lake of the Woods

Client Rolse Cascade

DAM INSPECTION CHECK LIST

UPSTREAM SLOPE

1. EROSION

A. SLOPE ABOVE WATER

No erosion - good condition

B. SLOPE BELOW WATER

Could not see below water line

C. RIPRAP

Good condition

D. RIPRAP FILTER

Good condition

2. ANIMAL BURROWS

None seen

3. CRACKS

None

4. SLIDES OR SLOUGHS

None

5. REMARKS

Generally good condition

TOP OF EMBANKMENT

1. CRACKS

None

2. SETTLEMENT (OR CONSOLIDATION)

Some - check profile

3. DRAINAGE OF TOP (EROSION, etc.)

Poor - should fill & regrade to slope to Lake

4. ANIMAL BURROWS

None

5. REMARKS

Run profile, bring to planned elevation or higher thruout

ABUTMENTS

1. EROSION AT CONTACT OF EMBANKMENT & ABUTMENT

Some (should sod)

2. SEEPAGE AT JUNCTION OF EMBANKMENT & ABUTMENT

None

3. EROSION FROM SURFACE DRAINAGE

Not serious

4. WET SPOTS AT ABUTMENT

None

5. SPRINGS - GULLIES - BOILS - etc.

None

6. REMARKS

Generally in good condition

DOWNSTREAM SLOPE

1. CRACKS

None

2. SLIDES OR SLOUGHS

None

3. SEEPAGE

At drains only which is proper

Job No. _____ Date _____
Job Name _____
Client _____

| | |
|--------------------------------|---|
| 4. BRUSH | None |
| 5. DAMP OR WET "BANDS" | None |
| 6. FILTER - FREE DRAINING ? | Yes |
| 7. PIPE DRAIN - OBSTRUCTIONS ? | None |
| 8. SLOPE EROSION | Some - should repair and seed or sod |
| 9. REMARKS | In general looks good - slight erosion should be repaired. No need to worry about wet spots these will gradually diminish |
| DOWNSTREAM FROM TOE | |
| 1. BOILS | None |
| 2. EROSION GULLIES | None |
| 3. OTHER WET SPOTS | None noticed |
| 4. REMARKS | OK |

| | | |
|-------------------------------|----|--|
| 1. COMPARE WITH PLANS | 3. | OK |
| 2. DEBRIS | | None |
| 3. CRACKS | | Slight 1/8" to hairline, not serious at this time, eventually filled |
| 4. HOLLOW CONCRETE | | None |
| 5. SLIDE GATE | | Leaks - should adjust wedges |
| 6. EROSION AROUND WALLS, etc. | | None |
| 7. REINFORCING STEEL EXPOSED | | None |
| 8. OUTLET CHANNEL | | OK |
| 9. REMARKS | | Generally in excellent condition |

BAUER
ENGINEERING,
INC.

Job No. 193.001 Date 8/17/70
Job Name Lake of the Woods
Client Boise Cascade

DAM INSPECTION CHECK LIST

UPSTREAM SLOPE

1. EROSION

A. SLOPE ABOVE WATER

No erosion - good condition

B. SLOPE BELOW WATER

Could not see below water line

C. RIPRAP

Good condition

D. RIPRAP FILTER

Good condition

2. ANIMAL BURROWS

None seen

3. CRACKS

None

4. SLIDES OR SLOUGHS

None

5. REMARKS

Generally good condition

TOP OF EMBANKMENT

1. CRACKS

None

2. SETTLEMENT (OR CONSOLIDATION)

Some - check profile

3. DRAINAGE OF TOP (EROSION, etc.)

Poor - should fill & regrade to slope to Lake

4. ANIMAL BURROWS

None

5. REMARKS

Run profile, bring to planned elevation or higher throughout

ABUTMENTS

1. EROSION AT CONTACT OF EMBANKMENT & ABUTMENT

Some (should sod)

2. SEEPAGE AT JUNCTION OF EMBANKMENT & ABUTMENT

None

3. EROSION FROM SURFACE DRAINAGE

Not serious

4. WET SPOTS AT ABUTMENT

None

5. SPRINGS - GULLIES - BOILS - etc.

None

6. REMARKS

Generally in good condition

DOWNSTREAM SLOPE

1. CRACKS

None

2. SLIDES OR SLOUGHS

None

3. SEEPAGE

at drains only which is proper

Job No. _____ Date _____
Job Name _____
Client _____

| | |
|--------------------------------|---|
| 4. BRUSH | None |
| 5. DAMP OR WET "BANDS" | None |
| 6. FILTER - FREE DRAINING ? | Yes |
| 7. PIPE DRAIN - OBSTRUCTIONS ? | None |
| 8. SLOPE EROSION | Some - should repair and seed or top |
| 9. REMARKS | In general looks good - slight erosion should be repaired. No need to worry about wet spots these will gradually diminish |
| DOWNSTREAM FROM TOE | |
| 1. BOILS | None |
| 2. EROSION GULLIES | None |
| 3. OTHER WET SPOTS | None noticed |
| 4. REMARKS | OK |

| 1. COMPARE WITH PLANS. | OK |
|-------------------------------|---|
| 2. DEBRIS | None |
| 3. CRACKS | Slight 1/8" to hairline, not serious at this time, eventually should fill |
| 4. HOLLOW CONCRETE | None |
| 5. SLIDE GATE | Leaks - should adjust wedges |
| 6. EROSION AROUND WALLS, etc. | None |
| 7. REINFORCING STEEL EXPOSED | None |
| 8. OUTLET CHANNEL | OK |
| 9. REMARKS | Generally in excellent condition |

FACILITIES STUDY

**MARTIN, CLIFFORD & ASSOCIATES
STAFFORD, WILLIAMSBURG AND
CHARLOTTESVILLE, VIRGINIA**

SECTION IV

DAMS, SPILLWAYS AND LAKES

Situated within the confines of the Lake of the Woods development, are two lakes, one approximately 500 acres and the other 25 acres. The larger one is intended for water skiing, sailboating, swimming and other recreational purposes, whereas the smaller lake is mainly for fishing. The large lake was reviewed in two basic areas, lake portion and spillway and dam portion with the following appropriate comments:

Lake

One of the main concerns of the lake was the possibility of silt deposits. In order to evaluate this situation, fathometer readings were taken and recorded. See attached schedule and location map at the end of this section. Certain discrepancies were found between the readings taken and the topographical data that was made available. It is believed that this could be accountable to the fact that the topographical information was not "as-built", that is, up-dated after construction of the facility was completed.

The readings taken do not show an appreciable difference, or unexplainable difference between the topographical information and the soundings taken, but it must be borne in mind that the readings were taken on just one occasion, and as such, it is difficult to compare them with the information that was made available. Although a significant difference is not shown, these same readings should be taken on a periodic basis to insure that the build-up of silt is not occurring. It is interesting to note that of the twelve point samples taken, those in the finger areas where silting would seem to be occurring, such as in the vicinity of Tidewater Street, the difference between the topo and the soundings is negligible.

In certain areas of the shoreline, some of the lot owners have attempted to protect their banks by placing rip-rap. Normal water level being elevation 317.5, this rip-rap should be laid two feet above and below this level to assure sufficient coverage during anticipated variance. The sections covered in this manner noticeably prevented shortly, the effects of erosion of the property compared to the adjoining lots have none. The wave action from both the prevailing winds and the passage of speedboats will necessitate this or some other similar method be undertaken by all owners of waterfront lots. As the majority of this work could be done by a barge working from the lake, it would be an economic advantage to the owners to employ one contractor to do the entire undertaking.

Spillway and Dam

The major evaluation of this section was accomplished by reviewing the drawings prepared by the Bauer Engineering Company, and the files available at the office of the Attorney, Mr. Moore, in Orange County. The files included such items as design criteria and calculations; correspondence among the design engineer and the engineering firm employed to review their work, the developer and the contractor who performed the work; and daily time sheets of the inspector who was present during construction.

The files indicate that there were minor differences of opinion between the two engineering firms, but no significant differences concerning final plans on all major items. Our review of the plans indicate that all is according to sound engineering principals, and was executed in a professional manner. In calculation of a flood routing for a 100 year storm, the difference between their figure (320.0) and ours (319.5) was six inches. This is a relatively insignificant difference, and the discrepancies could be attributed to the method selected.

The crack in the spillway wall adjacent to the gate structure was inspected and it is reasonable to assume that it was caused by a temperature change. Over a period of time the entrance of water will cause freezing and thawing problems along with deterioration to the reinforcing steel. With this in mind, this crack will eventually have to be repaired.

The concrete walls of the spillway show practically no signs of wear. The spillway itself is spalling in some areas, but compared to the thickness of the concrete, it is of little consequence. Possibly after several years a thin coating of new concrete should be applied. This is frequently done with concrete structures and will restore the spillway to a new appearance after it has been exposed to the elements for many years.

The seeding of the bank of the dam was at one time somewhat of a problem to the maintenance people. With the advice and aid from the Soil Conservation Service, the crews are now conditioning the soil with lime and adding fertilization with noticeably good results. Assuming this plan is followed on a regular basis, adequate vegetation will remain on the banks.

On the down stream side of the dam there is a certain amount of moisture constantly present in two locations. One is located to the west of the outlet valve and the other is to the east of the bottom of the spillway. Although no soil borings were taken of the area, it was felt that both problems are attributable to the impermeability of the soil at these locations and not a fault of the dam. By providing drainage ditches or conduits the water can easily be directed to the water discharging from the outlet valve and the spillway.

On two separate occasions, samples were collected from the two lakes. The samples were taken directly to our water chemistry laboratory for analysis. The samples were preserved by refrigeration prior to testing.

APPENDIX VI

REPORT OF SOILS EXPLORATION

REPORT OF SOILS EXPLORATION

**PROPOSED DAM-LAKE OF THE WOODS RESERVOIR
ORANGE COUNTY, VIRGINIA**

FOR

BAUER ENGINEERING, INC.

5651-001-07



DAMES & MOORE

CONSULTANTS IN APPLIED EARTH SCIENCES
SOIL MECHANICS • ENGINEERING GEOLOGY • GEOPHYSICS

ATLANTA NEW YORK
CHICAGO PORTLAND
HONOLULU SALT LAKE CITY
HOUSTON SAN FRANCISCO
LOS ANGELES SEATTLE
WASHINGTON
MADRID, SPAIN SAINT JOHN N.B. CANADA
TEHRAN IRAN

309 WEST JACKSON BOULEVARD • CHICAGO, ILLINOIS 60606 • 312-922-1772

PARTNERS: JAMES B. THOMPSON • GEORGE D. LEAL

October 21, 1966

Bauer Engineering, Inc.
20 North Wacker Drive
Chicago, Illinois 60606

Attention: Mr. William J. Bauer, President

Gentlemen:

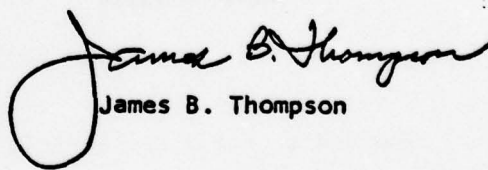
Ten copies of our "Report of Soils Exploration, Proposed Dam-Lake of the Woods Reservoir, Orange County, Virginia" are herewith submitted.

The scope of our soils exploration was planned in collaboration with Messrs. William J. Bauer, Robert L. Hall, and D. R. Knouse of Bauer Engineering, Inc.

Preliminary data were provided to Messrs. Bauer, Hall and Knouse during the course of the investigation.

Yours very truly,

DAMES & MOORE


James B. Thompson

JBT:WJG:mf

VI-1

CABLE ADDRESS DAMEMOOR

REPORT OF SOILS EXPLORATION
PROPOSED DAM-LAKE OF THE WOODS RESERVOIR
ORANGE COUNTY, VIRGINIA
FOR
BAUER ENGINEERING, INC.

INTRODUCTION

This report presents the results of our soils exploration performed at the site of the Proposed Dam-Lake of the Woods Reservoir to be constructed in Orange County, Virginia. The proposed dam will impound the water flowing in Flat Run Creek and the water derived from the upstream water shed area in the vicinity of the proposed dam. The proposed dam will be located approximately one-fifth of a mile upstream from where Flat Run Creek flows under Virginia State Highway 3. This is approximately 1 mile southeast of Flat Run, Virginia on Virginia State Highway 3.

The field explorations included the drilling of 18 test borings and the excavation of one test pit. The locations of the test borings and test pit are shown with respect to the proposed dam on Plate 1, Plot Plan.

SCOPE

The scope of our soils exploration were as follows:

- 1 - To explore the subsurface soil and water conditions at the dam site to the depths which will be influenced by the proposed construction.

- 2 - To determine the classification and pertinent physical characteristics including compaction and strength properties of representative materials encountered within the proposed borrow area.

GEOLOGY

The site of the Proposed Flat Run Creek Dam is located in an area known as the Piedmont Upland Province. This province is bordered on the west by the Appalachian Mountains and on the east by the Atlantic Coastal Plain. The typical landscape is a rolling surface of gentle slopes and no great relief. Average relief is approximately 50 to 100 feet.

The rock formations of the Piedmont Upland consist of gneisses, schists, slates and other metamorphic rocks, all of which have been deformed by mountain-making movements.

The soils of this area are basically residual with small areas of recent alluvial deposits around major streams. The residual soils are the products of weathering of the generally strong metamorphic rocks. The residual soil is quite thick in some localities and thus sound rock will usually be at considerable depths.

SURFACE CONDITIONS

The site of the proposed dam is located within a small broad valley which contains Flat Run Creek. The flow of Flat Run Creek is to the north. The maximum relief in the immediate area is approximately 85 feet. At the present time, the majority of the land around the proposed dam is wooded.

SUBSURFACE CONDITIONS

The subsurface conditions encountered at the site are as follows:

- 1 - Brown silty topsoil
- 2 - Reddish brown silty clay and clayey silt
- 3 - Mottled brown and gray sandy silt (decomposed rock)
- 4 - Highly weathered rock (gneiss)

All of the soils in the area investigated are basically residual in origin except for a few recent alluvial sand and gravel deposits along Flat Run Creek. The thickness of the topsoil varies throughout the site with greater depths being found on gentle slopes and flat areas. Underlying this topsoil is a reddish brown silty clay and clayey silt. The thickness of this soil is generally on the order of five feet. In the areas around Boring XIV and adjacent to Flat Run Creek this soil is absent. This absence is probably due to the erosional affect of Flat Run Creek. Underlying this stratum there is a layer of mottled brown and gray sandy silt (decomposed rock). The structure of the rock from which this residual soil has formed can still be seen in undisturbed samples obtained from this stratum. Below the mottled brown and gray sandy silt (decomposed rock) weathered gneiss is encountered. To assist you in visualizing the subsurface conditions encountered at the site of the proposed dam, graphical illustrations are presented on Plates 2A and 2B, Subsurface Sections.

--oOo--

The following Plates and Appendix are attached and complete this report:

Plate 1 - Plot Plan

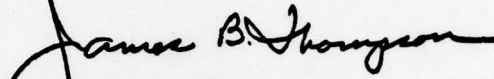
Plate 2A - Subsurface Section A-A

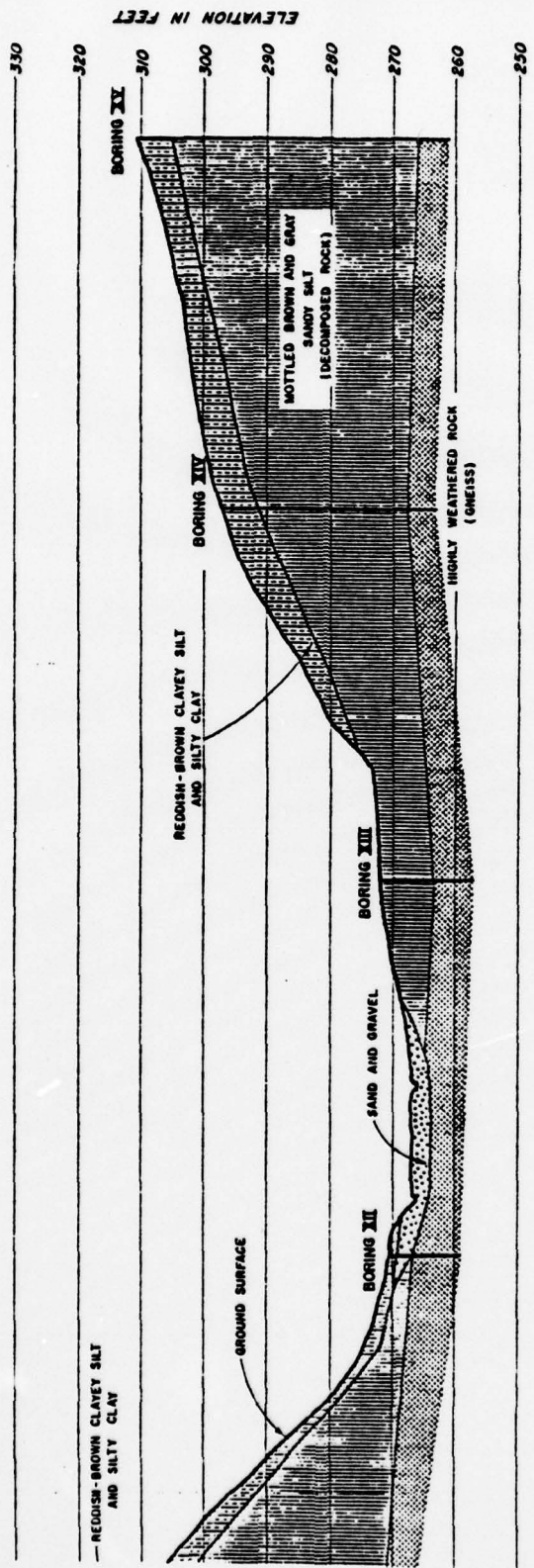
Plate 2B - Subsurface Section B-B

Appendix - Explorations And Laboratory Tests

Respectfully submitted,

DAMES & MOORE


James B. Thompson



SUBSURFACE SECTION A-A



VI-7

AD-A073 631

BAKER (MICHAEL) JR INC BEAVER PA
NATIONAL DAM SAFETY PROGRAM. LAKE OF THE WOODS,
MAR 79 M BAKER

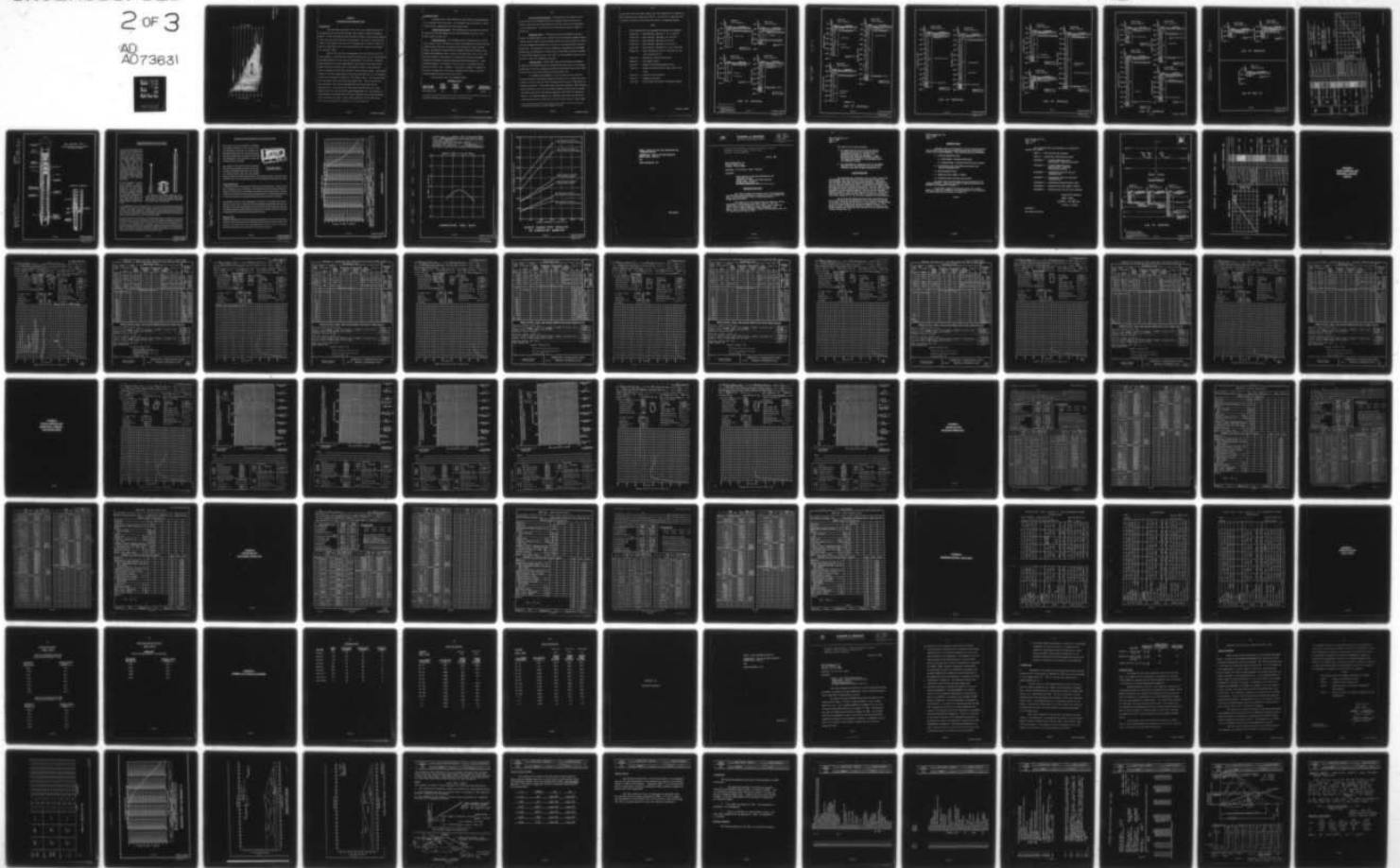
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2 OF 3

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APPENDIX
EXPLORATIONS AND LABORATORY TESTS

EXPLORATIONS:

The subsurface conditions at the site of the proposed dam were investigated by drilling 18 test borings, which ranged in depth from approximately 11 to 56 feet below the existing ground surface, utilizing truck mounted rotary wash and rotary auger drilling equipment. One test pit was also excavated in the proposed borrow area of the proposed dam in order to visually inspect the subsurface soils to be used as borrow and to obtain a bulk sample for laboratory tests.

The drilling and test pit operations were supervised by one of our field engineers, who maintained a log of the borings and test pit and obtained undisturbed samples of soils and rock encountered in the borings. Graphical representation of the soils encountered in the borings and the test pit are shown on Plate A-1A through A-1F. The method utilized in classifying the soils is defined on Plate A-2, Unified Soil Classification System. Undisturbed samples of the soils penetrated by the borings were obtained in a soil sampler of the type illustrated on Plate A-3, Soil Sampler Type U. The rock was cored utilizing double tube core barrels and diamond bits. The boring locations were obtained in the field by representatives from the Prince William Engineering Co. The elevations of the borings were obtained from a topographic map of the area provided by Bauer Engineering, Inc. The ground surface elevation is presented above the log of each boring and these elevations refer to the U.S.G.S. Datum. Water levels recorded in the borings during our field investigation are presented on the Log of Borings.

LABORATORY TESTS:

Laboratory tests were performed on bulk samples of proposed borrow soil excavated from the test pit. The laboratory tests consisted of identification tests, compaction tests and strength tests.

Identification Tests - The Atterberg Limits and particle size distribution of the bulk samples of soil were determined to assist in the identification of the soil.

Atterberg Limits - The Atterberg Limits, consisting of the liquid limit, plastic limit, and plasticity index, were determined to facilitate the classification of the soil according to the Unified Soil Classification System. The method of performing the Atterberg Limits may be found in most standard Soil Mechanics texts. Briefly, the liquid limit of a soil is that moisture content at which the soil is practically liquid but presumably possesses the smallest shearing strength which may be measured by a standardized procedure. The plastic limit of a soil is the lowest moisture content of which a soil is plastic. The plasticity index is a measure of the plastic properties of soils and is defined as the range in moisture content between the plastic and liquid limits.

The Atterberg Limits are tabulated below:

ATTERBERG LIMITS

| <u>TEST PIT AND DEPTH IN FEET</u> | <u>LIQUID LIMIT PERCENT*</u> | <u>PLASTIC LIMIT PERCENT*</u> | <u>PLASTICITY INDEX</u> | <u>UNIFIED SOIL CLASSIFICATION</u> |
|---------------------------------------|--------------------------------------|---------------------------------------|-----------------------------|--|
| TP-1 @ 2½ to 3½ | 39 | 24 | 15 | ML-CL |

* Moisture content expressed as percent of the dry weight.

Particle Size Distribution - Determination of the particle size distribution of the proposed borrow soil obtained from the test pit was made to facilitate the classification of the soil and to aid in the design of the proposed dam. The particle size distribution curves are shown on Plate A-6.

Compaction Tests - A compaction test was performed on the bulk sample of proposed borrow soil to determine the relationship between moisture content and dry density under controlled conditions and to establish criteria for the placement and compaction of the soil in the construction of the proposed dam. The compaction test was performed in accordance with the AASHO* Compaction Test Designation T 180-57 which is described on Plate A-4, Method of Performing Compaction Tests. The results of the compaction test are presented on Plate A-7, Compaction Test Data.

Strength Tests - Direct shear tests were performed on compacted samples of the proposed borrow soil obtained from the test pit in the manner described on Plate A-5, Method of Performing Direct Shear and Friction Tests. Stress-strain curves were plotted for each strength test.

Six samples were compacted a little on the dry side of optimum moisture content to 90 percent maximum dry density and six samples were compacted a little on the dry side of optimum moisture content to 95 percent of maximum dry density. Direct shear tests were then performed, under different normal pressures, on half of the samples compacted to 90 percent of maximum dry density and half of the samples compacted to 95 percent of maximum dry density. The remaining samples were submerged under water and various surcharge pressures for five days prior to direct shear testing. Direct shear

* American Association of State Highway Officials

tests were also run on other samples that were compacted wet of optimum to 84 and 88 percent of maximum dry density. The results of these tests are plotted on Plate A-8, Direct Shear Test Results on Compacted Samples.

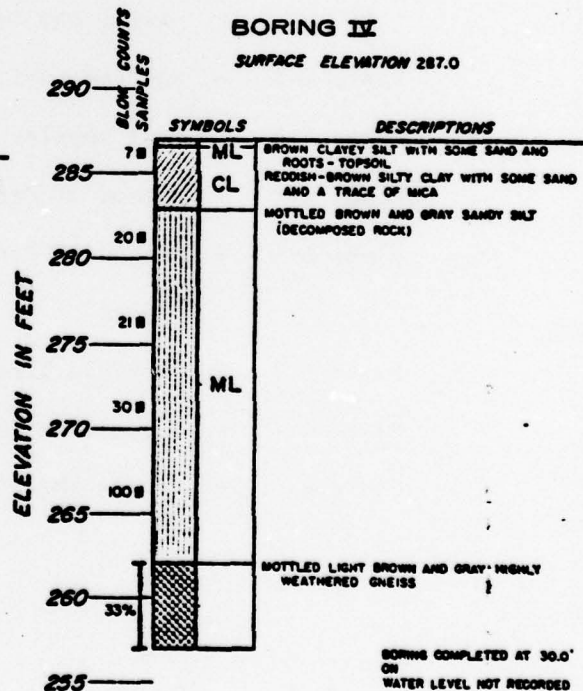
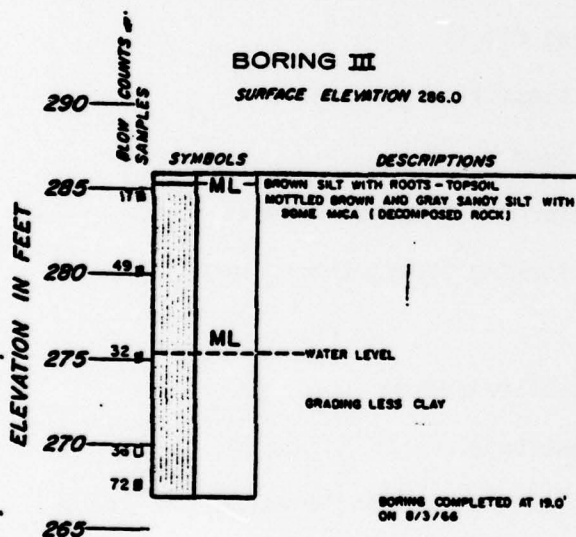
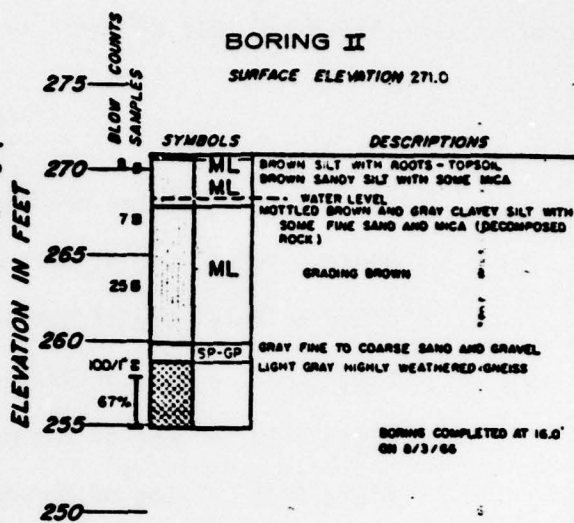
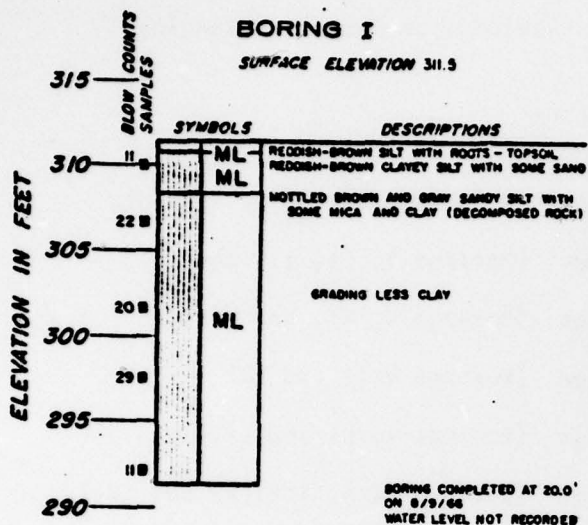
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The following Plates are attached and complete this Appendix:

- Plate A-1A - Log of Borings (Borings I, II, III and IV)
- Plate A-1B - Log of Borings (Borings V, VI, and VII)
- Plate A-1C - Log of Borings (Borings VIII and IX)
- Plate A-1D - Log of Borings (Borings X, XI and XII)
- Plate A-1E - Log of Borings (Borings XIII, XIV, XV and XVI)
- Plate A-1F - Log of Borings and Test Pit (Borings XVII and XVIII and Test Pit 1)

- Plate A-2 - Unified Soil Classification System
- Plate A-3 - Soil Sampler Type U
- Plate A-4 - Method of Performing Compaction Tests
- Plate A-5 - Method of Performing Direct Shear and Friction Tests

- Plate A-6 - Particle Size Distribution
- Plate A-7 - Compaction Test Data
- Plate A-8 - Direct Shear Test Results on Compacted Samples



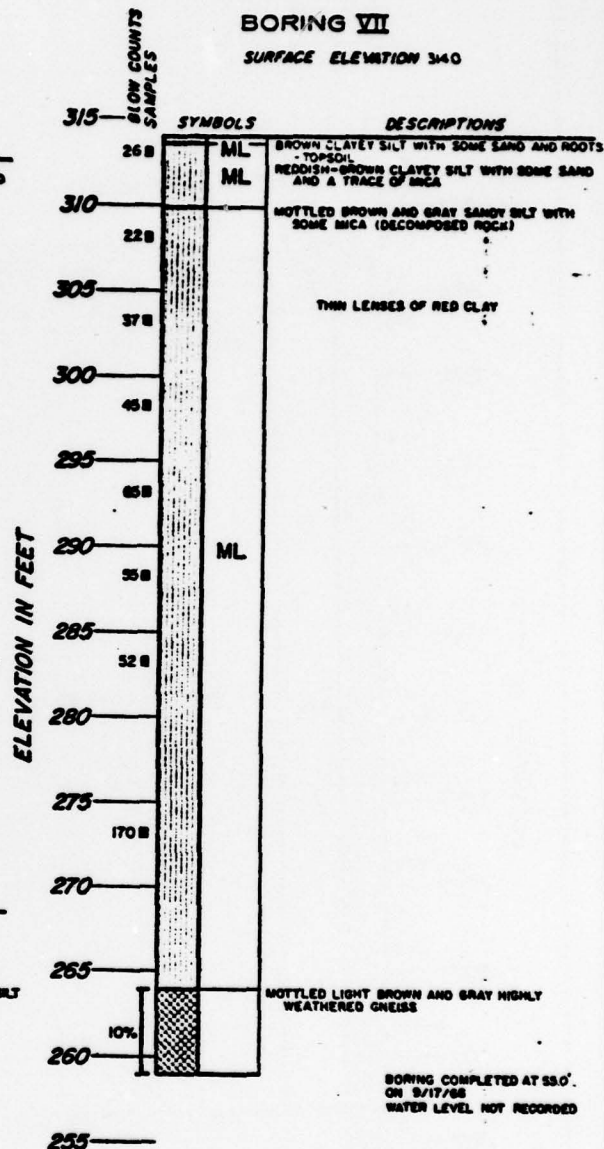
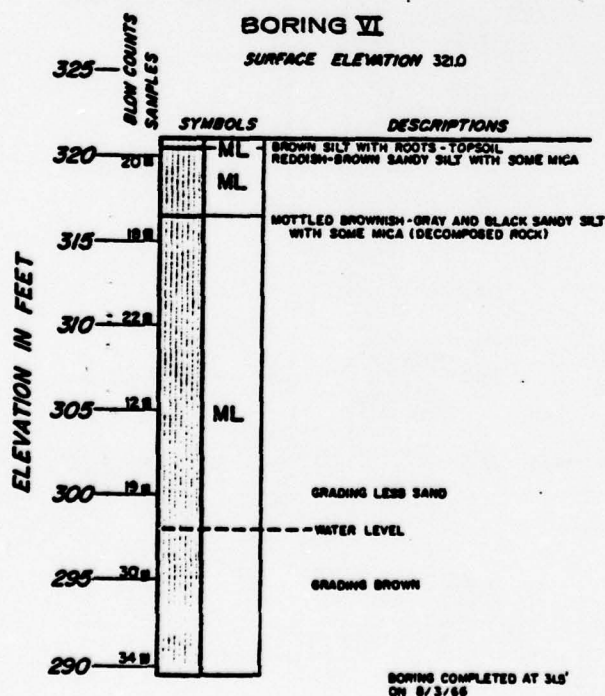
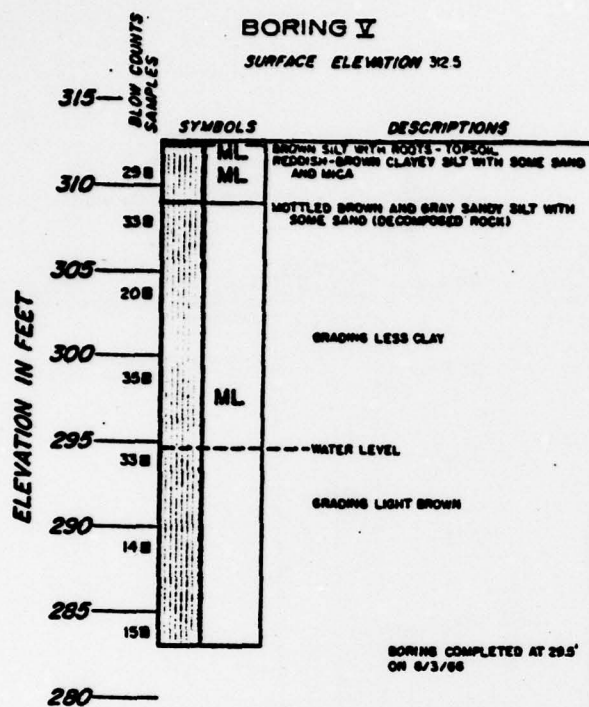
LOG OF BORINGS

NOTES:
ELEVATIONS REFER TO U.S.G.S. DATUM.

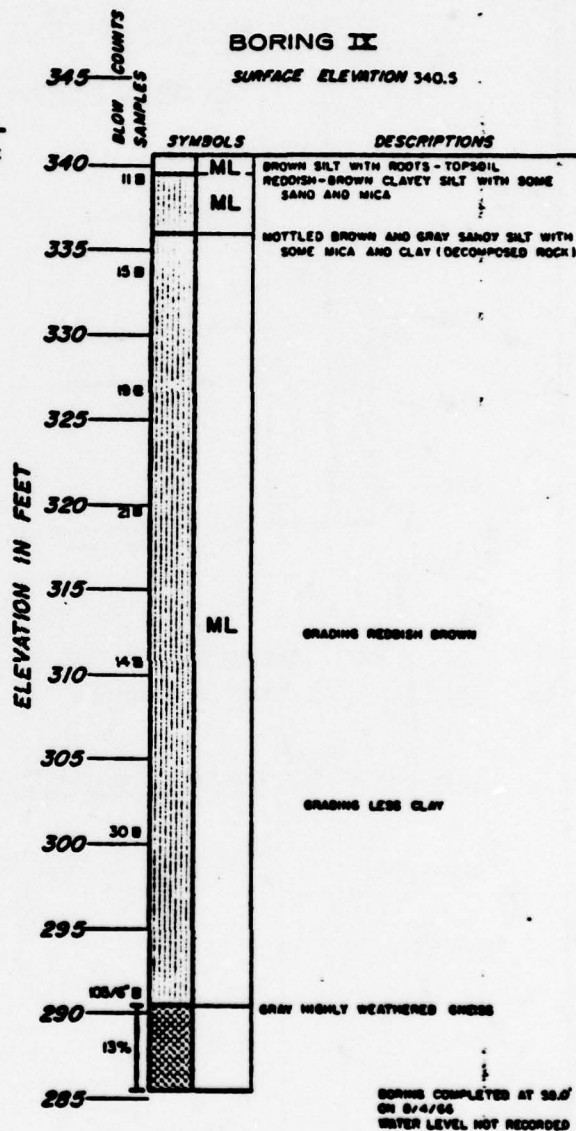
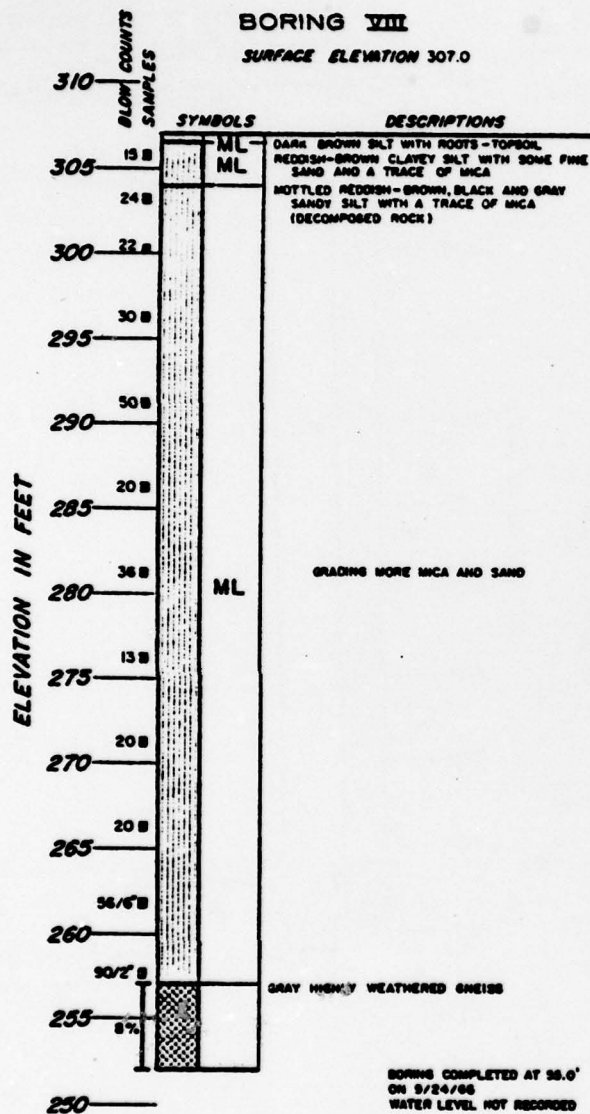
100% I INDICATES DEPTH, LENGTH AND PERCENT OF CORE RUN RECOVERED.
FIGURES UNDER THE BLOW COUNT COLUMN INDICATE THE NUMBER OF BLOWS REQUIRED TO DRIVE A DAPES & MOORE SAMPLER ONE-FOOT WITH A 300 LB. WEIGHT FALLING 12 INCHES.

BY *E. K.* DATE *8/11/66*
 CHECKED BY *...* DATE *...*

BY *E. K.* DATE *8/11/66*
 CHECKED BY *...* DATE *...*



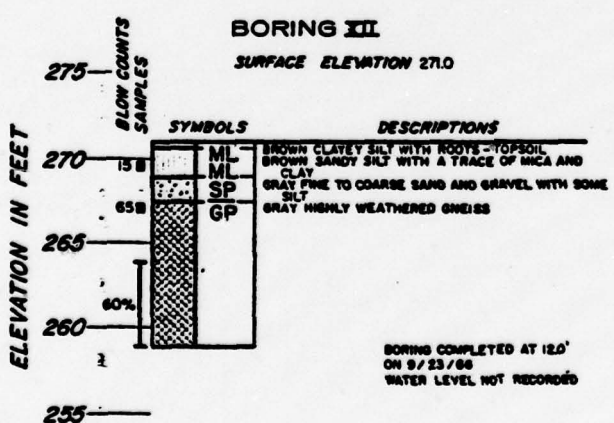
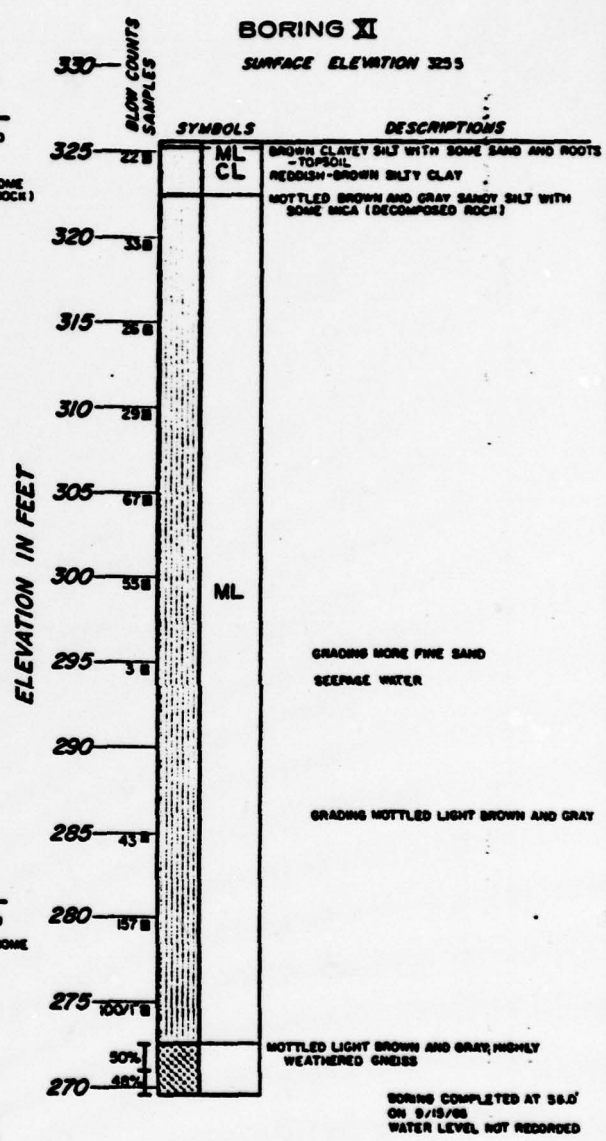
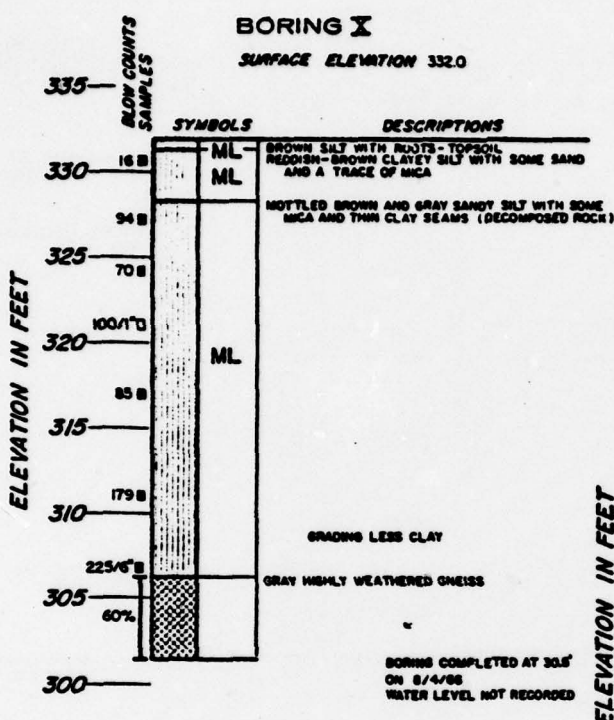
LOG OF BORINGS



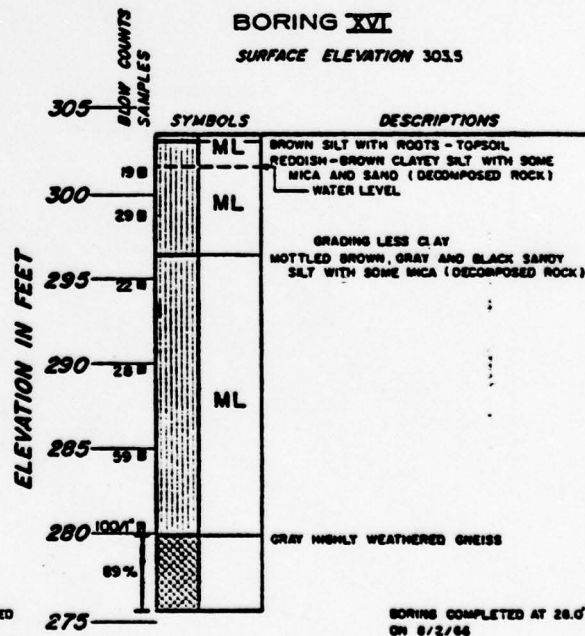
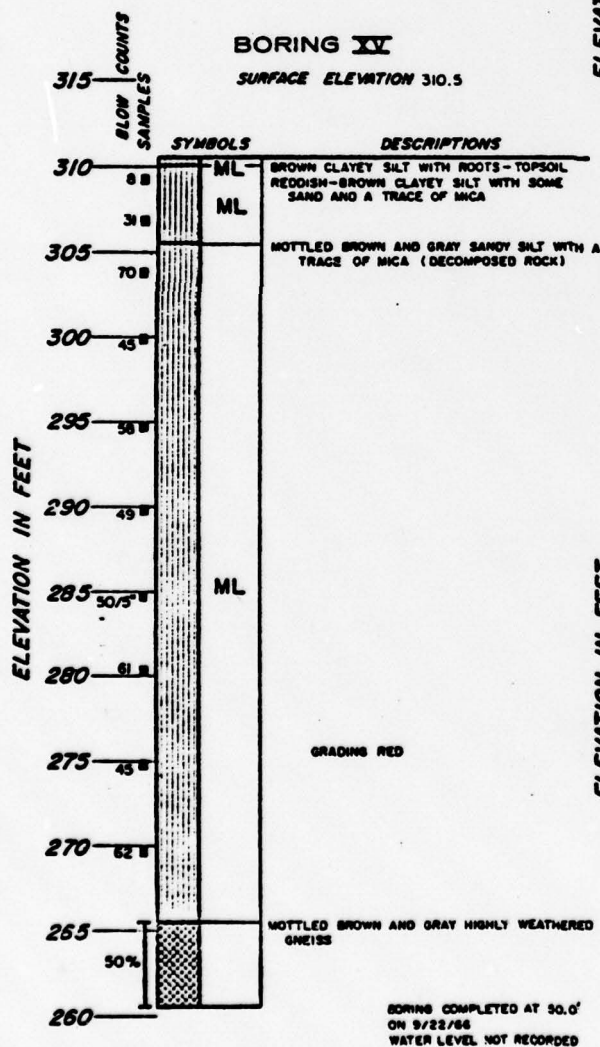
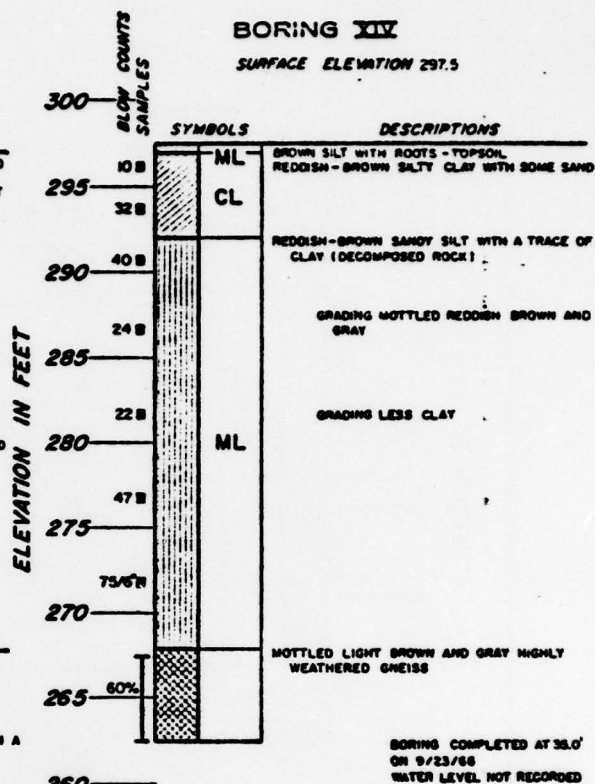
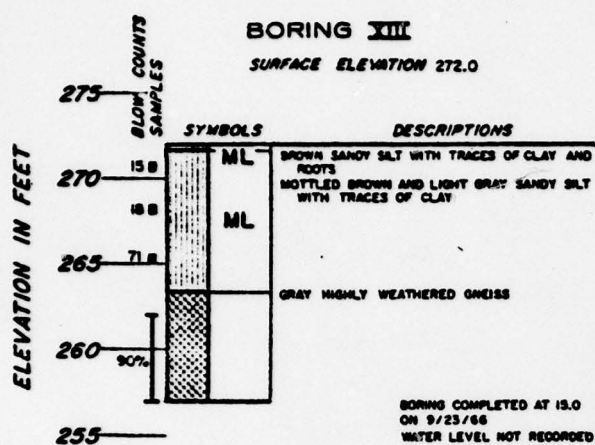
LOG OF BORINGS

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 BY: _____ DATE: _____
 CHECKED BY: _____ DATE: _____

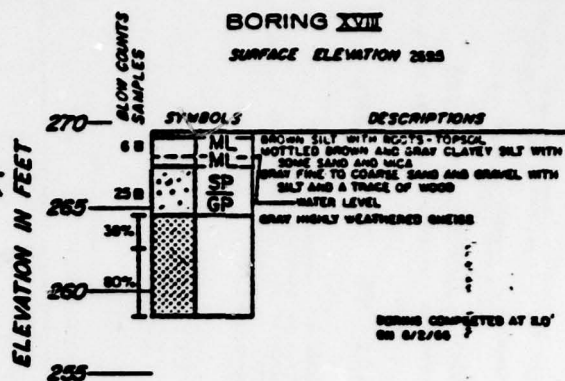
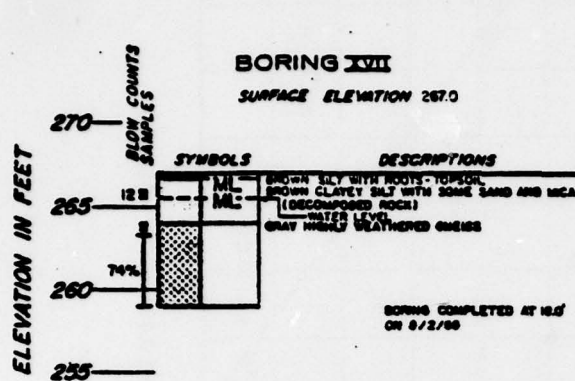
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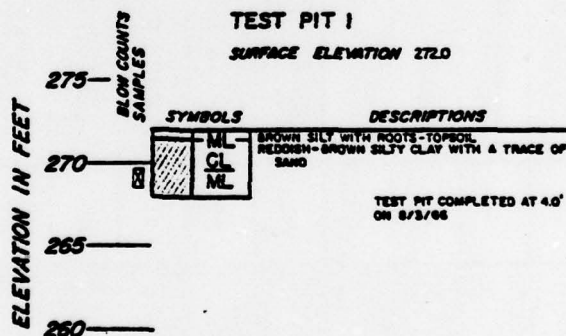
LOG OF BORINGS



LOG OF BORINGS



LOG OF BORINGS



LOG OF TEST PIT

THE UNIT FIELD MEASUREMENTS ARE PLACED IN A COLUMN OF THE RIGHT HAND OF THE
 BUT RESULT EXPRESSED IN POUNDS PER SQUARE FOOT

ROCK COMPRESSION TESTS

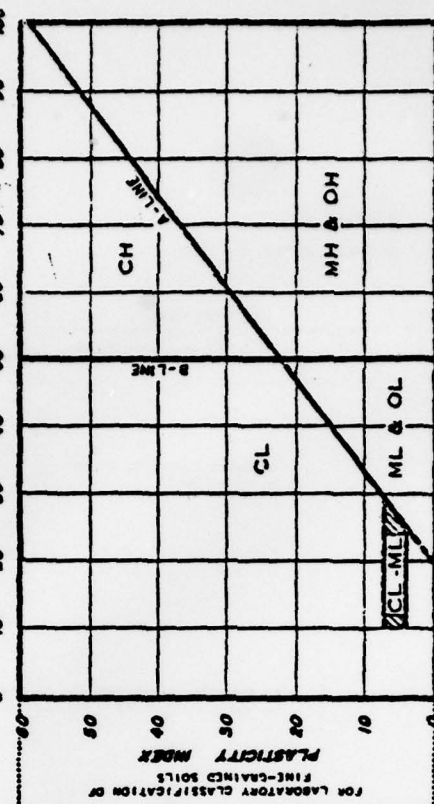
COMPRESSIVE STRENGTH IN POUNDS PER SQUARE INCH

KEY TO TEST DATA

- INDICATES DEPTH OF UNDISTURBED SAMPLE
- INDICATES DEPTH OF DISTURBED SAMPLE
- INDICATES DEPTH OF SAMPLING ATTEMPT WITH NO RECOVERY
- INDICATES DEPTH OF SPIT-SPUN SAMPLE
- INDICATES DEPTH AND LENGTH OF CORING RUN

KEY TO SAMPLES

LIQUID LIMIT



PLASTICITY CHART

| COARSE GRAINED SOILS | CLAYEY SOILS | CLAYEY GRAVELS (LITTLE OR NO FINES) | GP | GM | GC | SW | SP | SM | SC | ML | CL | OL | MH | CH | OH | PT |
|---|---|--|---|-------------------------------------|--------------------------------------|---|---|---------------------------------|----------------------------------|--|---|---|---|---|---|---|
| MORE THAN 50% OF MATERIAL IS COARSE FRAGMENTS PASSING NO. 4 SIEVE | MORE THAN 50% OF MATERIAL IS COARSE FRAGMENTS PASSING NO. 4 SIEVE | GRAVELS WITH FINES (APPROPRIATE AMOUNT OF FINES) | POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES | SILTY GRAVELS, GRAVEL-SAND MIXTURES | CLAYEY GRAVELS, GRAVEL-SAND MIXTURES | WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES | POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES | SILTY SANDS, SAND-SILT MIXTURES | CLAYEY SANDS, SAND-CLAY MIXTURES | INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY | INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LOAM CLAYS | ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS | INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS | ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS | PEAT, MARLS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS |
| MORE THAN 50% OF MATERIAL IS FINER THAN NO. 200 SIEVE SIZE | MORE THAN 50% OF MATERIAL IS FINER THAN NO. 200 SIEVE SIZE | CLAYEY GRAVELS (LITTLE OR NO FINES) | GP | GM | GC | SW | SP | SM | SC | ML | CL | OL | MH | CH | OH | PT |
| MORE THAN 50% OF MATERIAL IS FINER THAN NO. 200 SIEVE SIZE | MORE THAN 50% OF MATERIAL IS FINER THAN NO. 200 SIEVE SIZE | CLAYEY GRAVELS (LITTLE OR NO FINES) | GP | GM | GC | SW | SP | SM | SC | ML | CL | OL | MH | CH | OH | PT |
| MORE THAN 50% OF MATERIAL IS FINER THAN NO. 200 SIEVE SIZE | MORE THAN 50% OF MATERIAL IS FINER THAN NO. 200 SIEVE SIZE | CLAYEY GRAVELS (LITTLE OR NO FINES) | GP | GM | GC | SW | SP | SM | SC | ML | CL | OL | MH | CH | OH | PT |

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

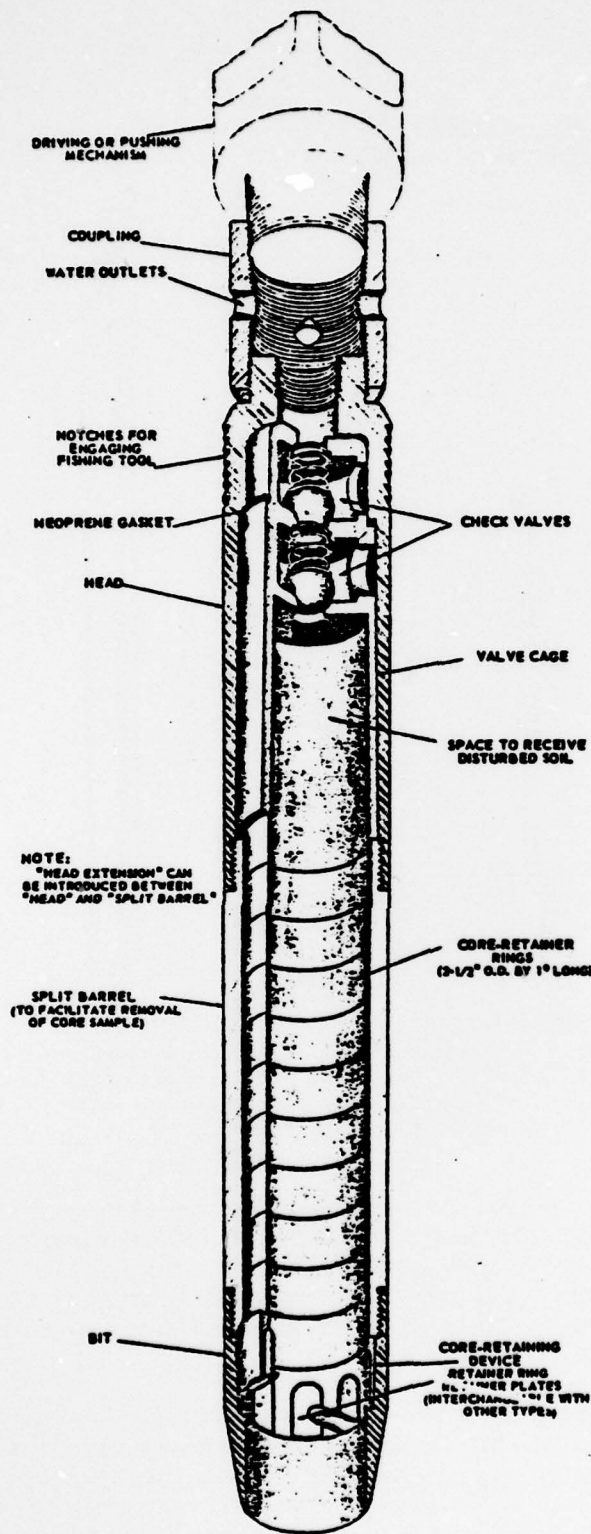
UNIFIED SOIL CLASSIFICATION SYSTEM

REVISIONS

BY _____ DATE _____
BY _____ DATE _____

FILE _____

BY _____ DATE _____
CHECKED BY _____
COPY TO GO _____



NOTE:
"HEAD EXTENSION" CAN
BE INTRODUCED BETWEEN
"HEAD" AND "SPLIT BARREL"

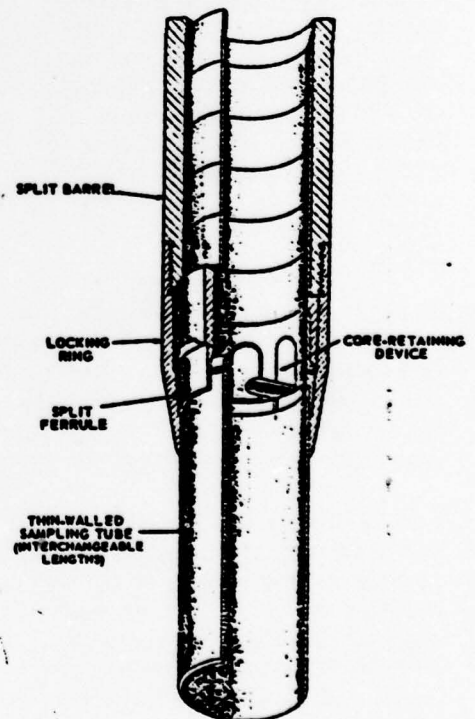
SPLIT BARREL
(TO FACILITATE REMOVAL
OF CORE SAMPLE)

BIT

CORE-RETAINING
DEVICE
RETAINER RING
No. 1-1/2\"/>

SOIL SAMPLER TYPE U
FOR SOILS DIFFICULT TO RETAIN IN SAMPLER
U. S. PATENT NO. 2,318,062

ALTERNATE ATTACHMENTS



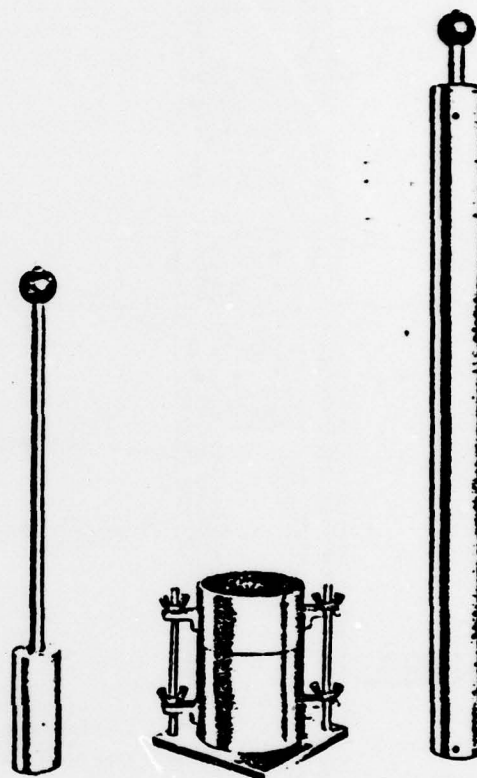
METHOD OF PERFORMING COMPACTION TESTS
(STANDARD AND MODIFIED A.A.S.H.O. METHODS)

IT HAS BEEN ESTABLISHED THAT WHEN COMPACTING EFFORT IS HELD CONSTANT, THE DENSITY OF A ROLLED EARTH FILL INCREASES WITH ADDED MOISTURE UNTIL A MAXIMUM DRY DENSITY IS OBTAINED AT A MOISTURE CONTENT TERMED THE "OPTIMUM MOISTURE CONTENT," AFTER WHICH THE DRY DENSITY DECREASES. THE COMPACTION CURVE SHOWING THE RELATIONSHIP BETWEEN DENSITY AND MOISTURE CONTENT FOR A SPECIFIC COMPACTING EFFORT IS DETERMINED BY EXPERIMENTAL METHODS. TWO COMMONLY USED METHODS ARE DESCRIBED IN THE FOLLOWING PARAGRAPHS.

FOR THE "STANDARD A.A.S.H.O." (A.S.T.M. D698-58T & A.A.S.H.O. T99-57) METHOD OF COMPACTION A PORTION OF THE SOIL SAMPLE PASSING THE NO. 4 SIEVE IS COMPACTED AT A SPECIFIC MOISTURE CONTENT IN THREE EQUAL LAYERS IN A STANDARD COMPACTION CYLINDER HAVING A VOLUME OF 1/30 CUBIC FOOT, USING TWENTY-FIVE 12-INCH BLOWS OF A STANDARD 5-1/2 POUND RAMMER TO COMPACT EACH LAYER.

IN THE "MODIFIED A.A.S.H.O." (A.S.T.M. D-1557-58T & A.A.S.H.O. T 180-57) METHOD OF COMPACTION A PORTION OF THE SOIL SAMPLE PASSING THE NO. 4 SIEVE IS COMPACTED AT A SPECIFIC MOISTURE CONTENT IN FIVE EQUAL LAYERS IN A STANDARD COMPACTION CYLINDER HAVING A VOLUME OF 1/30 CUBIC FOOT, USING TWENTY-FIVE 18-INCH BLOWS OF A 10-POUND RAMMER TO COMPACT EACH LAYER. SEVERAL VARIATIONS OF THESE COMPACTION TESTING METHODS ARE OFTEN USED AND THESE ARE DESCRIBED IN A.A.S.H.O. & A.S.T.M. SPECIFICATIONS.

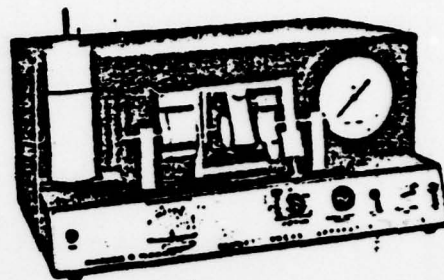
FOR BOTH METHODS, THE WET DENSITY OF THE COMPACTED SAMPLE IS DETERMINED BY WEIGHING THE KNOWN VOLUME OF SOIL; THE MOISTURE CONTENT, BY MEASURING THE LOSS OF WEIGHT OF A PORTION OF THE SAMPLE WHEN OVEN DRIED; AND THE DRY DENSITY, BY COMPUTING IT FROM THE WET DENSITY AND MOISTURE CONTENT. A SERIES OF SUCH COMPACTIONS IS PERFORMED AT INCREASING MOISTURE CONTENTS UNTIL A SUFFICIENT NUMBER OF POINTS DEFINING THE MOISTURE-DENSITY RELATIONSHIP HAVE BEEN OBTAINED TO PERMIT THE PLOTTING OF THE COMPACTION CURVE. THE MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT FOR THE PARTICULAR COMPACTING EFFORT ARE DETERMINED FROM THE COMPACTION CURVE.



SOME APPARATUS FOR PERFORMING COMPACTION TESTS
Shows, from left to right, 5-1/2 pound rammer (sleeve controlling 12" height of drop removed), 1/30 cubic-foot cylinder with removable collar and base plate, and 10 pound rammer within sleeve.

METHOD OF PERFORMING DIRECT SHEAR AND FRICTION TESTS

DIRECT SHEAR TESTS ARE PERFORMED TO DETERMINE THE SHEARING STRENGTHS OF SOILS. FRICTION TESTS ARE PERFORMED TO DETERMINE THE FRICTIONAL RESISTANCES BETWEEN SOILS AND VARIOUS OTHER MATERIALS SUCH AS WOOD, STEEL, OR CONCRETE. THE TESTS ARE PERFORMED IN THE LABORATORY TO SIMULATE ANTICIPATED FIELD CONDITIONS.



DIRECT SHEAR TESTING
& RECORDING APPARATUS

EACH SAMPLE IS TESTED WITHIN THREE BRASS RINGS, TWO AND ONE-HALF INCHES IN DIAMETER AND ONE INCH IN LENGTH. UNDISTURBED SAMPLES OF IN-PLACE SOILS ARE TESTED IN RINGS TAKEN FROM THE SAMPLING DEVICE IN WHICH THE SAMPLES WERE OBTAINED. LOOSE SAMPLES OF SOILS TO BE USED IN CONSTRUCTING EARTH FILLS ARE COMPACTED IN RINGS TO PREDETERMINED CONDITIONS AND TESTED.

DIRECT SHEAR TESTS

A THREE-INCH LENGTH OF THE SAMPLE IS TESTED IN DIRECT DOUBLE SHEAR. A CONSTANT PRESSURE, APPROPRIATE TO THE CONDITIONS OF THE PROBLEM FOR WHICH THE TEST IS BEING PERFORMED, IS APPLIED NORMAL TO THE ENDS OF THE SAMPLE THROUGH POROUS STONES. A SHEARING FAILURE OF THE SAMPLE IS CAUSED BY MOVING THE CENTER RING IN A DIRECTION PERPENDICULAR TO THE AXIS OF THE SAMPLE. TRANSVERSE MOVEMENT OF THE OUTER RINGS IS PREVENTED.

THE SHEARING FAILURE MAY BE ACCOMPLISHED BY APPLYING TO THE CENTER RING EITHER A CONSTANT RATE OF LOAD, A CONSTANT RATE OF DEFLECTION, OR INCREMENTS OF LOAD OR DEFLECTION. IN EACH CASE, THE SHEARING LOAD AND THE DEFLECTIONS IN BOTH THE AXIAL AND TRANSVERSE DIRECTIONS ARE RECORDED AND PLOTTED. THE SHEARING STRENGTH OF THE SOIL IS DETERMINED FROM THE RESULTING LOAD-DEFLECTION CURVES.

FRICTION TESTS

IN ORDER TO DETERMINE THE FRICTIONAL RESISTANCE BETWEEN SOIL AND THE SURFACES OF VARIOUS MATERIALS, THE CENTER RING OF SOIL IN THE DIRECT SHEAR TEST IS REPLACED BY A DISK OF THE MATERIAL TO BE TESTED. THE TEST IS THEN PERFORMED IN THE SAME MANNER AS THE DIRECT SHEAR TEST BY FORCING THE DISK OF MATERIAL FROM THE SOIL SURFACES.

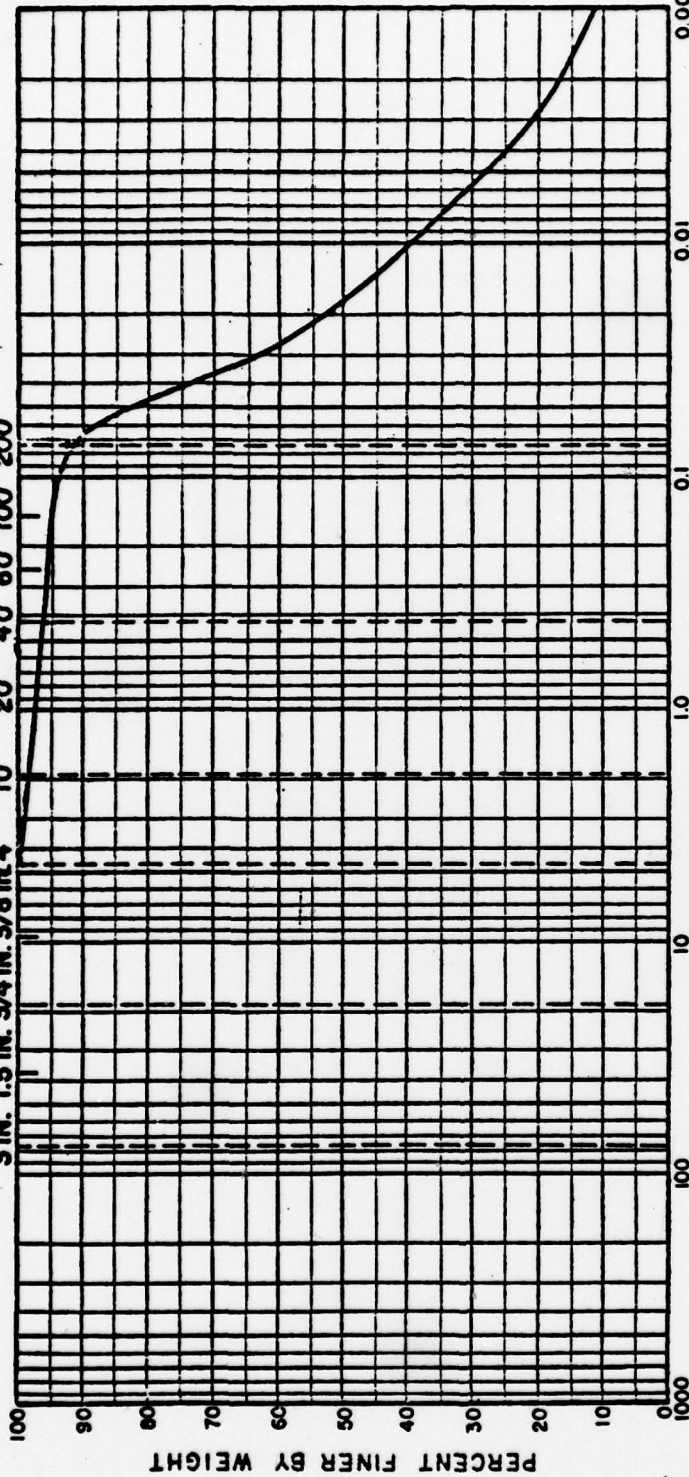
REVISIONS
BY _____ DATE _____

FILE _____

BY _____ DATE _____
CHECKED BY _____

U.S. STANDARD SIEVE SIZE

3 IN. 1.5 IN. 3/4 IN. 3/8 IN. 4 10 20 40 60 100 200



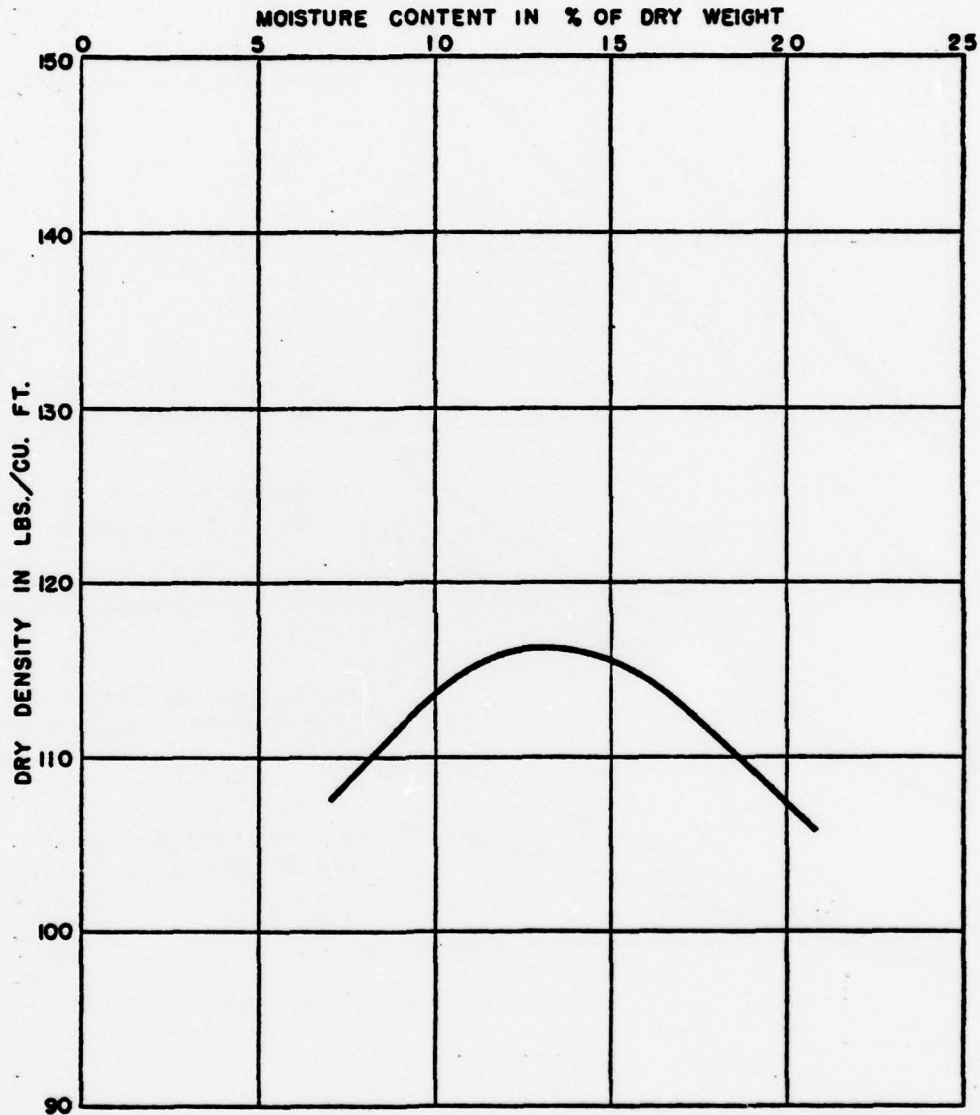
GRAIN SIZE IN MILLIMETERS

| COBBLES | | GRAVEL | | SAND | | | SILT OR CLAY | |
|---------|------|--------|--------|------|----|----|--------------|--|
| COARSE | FINE | COARSE | MEDIUM | FINE | LL | PL | PI | |

| LOCATION | DEPTH | CLASSIFICATION | NAT. WC | LL | PL | PI |
|------------|-------------|----------------------------|---------|----|----|----|
| TEST PIT 1 | 2.5' TO 35' | CL-ML SILTY CLAY WITH SAND | | 39 | 24 | 15 |

GRADATION CURVE

SAMPLE NO. 1 DEPTH 2.5' ELEVATION 269.5
 SOIL REDDISH-BROWN SILTY CLAY WITH TRACE OF SAND
 LOCATION TEST PIT 1
 OPTIMUM MOISTURE CONTENT 13.0 %
 MAXIMUM DRY DENSITY 116 LBS./CU. FT.
 METHOD OF COMPACTION A.A.S.H.O. T180-57(METHOD A)



COMPACTION TEST DATA

VI-25

DAMES & MOORE

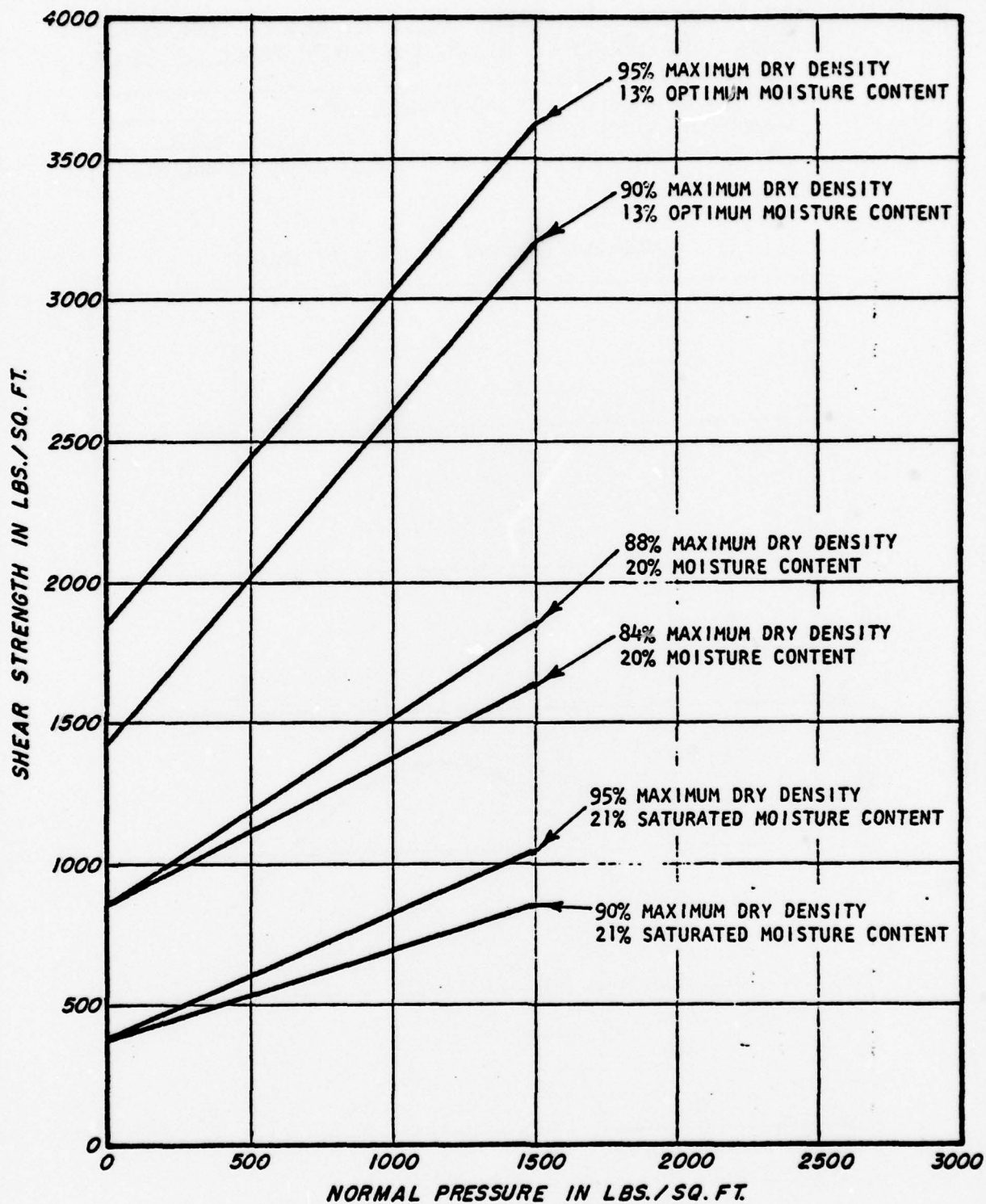
PLATE A-7

CHECKED BY _____ DATE _____

BY _____ DATE _____

BY _____ DATE _____

DATE 10/14/66



DIRECT SHEAR TEST RESULTS ON COMPACTED SAMPLES

VI-26

DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE A-8

**REPORT - RESULTS OF THE FIELD EXPLORATIONS AND
LABORATORY TESTING**

**PROPOSED DAM - LAKE OF THE WOODS RESERVOIR
ORANGE COUNTY, VIRGINIA**

FOR

BAUER ENGINEERING, INC.

5651-003-07



DAMES & MOORE
CONSULTANTS IN APPLIED EARTH SCIENCES
SOIL MECHANICS • ENGINEERING GEOLOGY • GEOPHYSICS

| | |
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| TEHRAN, IRAN | |

309 WEST JACKSON BOULEVARD • CHICAGO, ILLINOIS 60606 • 312-922-1772

PARTNERS: JAMES B. THOMPSON • GEORGE D. LEAL

ASSOCIATE: WILLIAM G. PARATORE

June 7, 1967

Bauer Engineering, Inc.
20 North Wacker Drive
Chicago, Illinois 60606

Attention: Mr. William J. Bauer, President

Gentlemen:

Report-Results of the Field Explorations and
Laboratory Testing
Proposed Dam - Lake of the Woods Reservoir
Orange County, Virginia
For Bauer Engineering, Inc.

INTRODUCTION AND SCOPE

This report presents the results of our field explorations and laboratory testing performed in connection with the Proposed Dam - Lake of the Woods Reservoir which is being constructed in Orange County, Virginia.

The scope of our field explorations and laboratory testing was planned in collaboration with Messrs. Robert L. Hall and Donald Wikan of Bauer Engineering, Inc., Messrs. Gay D. Jones and Jack W. Burke of Howard, Needles, Tammen & Bergendoff, and Messrs. John S. Keating and Robert L. Boone of United States Land, Inc. at a meeting held on May 10, 1967.

The scope of our services included:

- 1 - The supervision of the drilling and sampling of three exploration test borings drilled at approximately Station 7 + 25 within the partially constructed dam embankment. These operations were performed to obtain representative undisturbed samples of the embankment soils for laboratory testing.
- 2 - The performance of laboratory tests on the embankment soils and the presentation of the original laboratory test data to Bauer Engineering, Inc.

FIELD EXPLORATIONS

The subsurface soil conditions of the partially constructed dam embankment were explored by drilling three test borings with truck mounted, auger type caisson drilling equipment. The borings were 12 inches in diameter and penetrated through the embankment fill and into the underlying natural soils. Undisturbed soil samples were obtained from the test borings by hydraulically pushing a Dames & Moore Soil Sampler having a thin-wall bit extension. Two test pits were also excavated utilizing backhoe equipment. One test pit was excavated adjacent to Boring 1 and the other adjacent to Boring 3. Shelby tubes were hydraulically pushed into the sides of the test pits to obtain undisturbed samples of soil for horizontal permeability determinations.

The drilling and backhoe operations were supervised by one of our field engineers who maintained a log of the soils encountered. The location of the borings and test pits, and graphical representations of the soils penetrated by the borings are shown on Plate 1. The method utilized in classifying the soils is defined on Plate 2. The boring locations and elevations were provided to us by representatives of Bauer Engineering, Inc.

LABORATORY TESTS

Laboratory tests were performed on the soil samples obtained from the test borings and pits to obtain certain physical properties of the in-situ earth embankment. The following tests were performed:

- 1 - Triaxial Compression Tests
 - a - Consolidated - Undrained (Saturated)
 - b - Unconsolidated - Undrained (Field Moisture Content)
- 2 - Consolidation Tests (To determine horizontal and vertical permeabilities)
- 3 - Moisture-Density Tests
- 4 - Compaction Tests (AASHO T 180-57)
- 5 - Atterberg Limits and Grain Size Analyses

The above tests were performed utilizing conventional soil testing procedures. Copies of the original laboratory test data are presented in Attachments A through G.

It has been a pleasure to work with you on this project. Should you need any assistance in the interpretation of the laboratory test data, please do not hesitate to contact us.

--000--

Bauer Engineering, Inc.
June 7, 1967
Page - 4

The following Plates and Attachments are enclosed and complete this report:

Plate 1 - Plot Plan and Log of Borings

Plate 2 - Unified Soil Classification System

Attachment A - Triaxial Compression Tests
Consolidated - Undrained, Saturated

Attachment B - Triaxial Compression Tests
Unconsolidated - Undrained,
Field Moisture Content

Attachment C - Consolidation Tests For Vertical
Permeabilities

Attachment D - Consolidation Tests For Horizontal
Permeabilities

Attachment E - Supplementary Moisture-Density Tests

Attachment F - Compaction Test Data (AASHO T 180-57)

Attachment G - Atterberg Limits and Grain Size Analyses

Respectfully submitted,

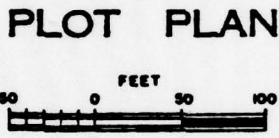
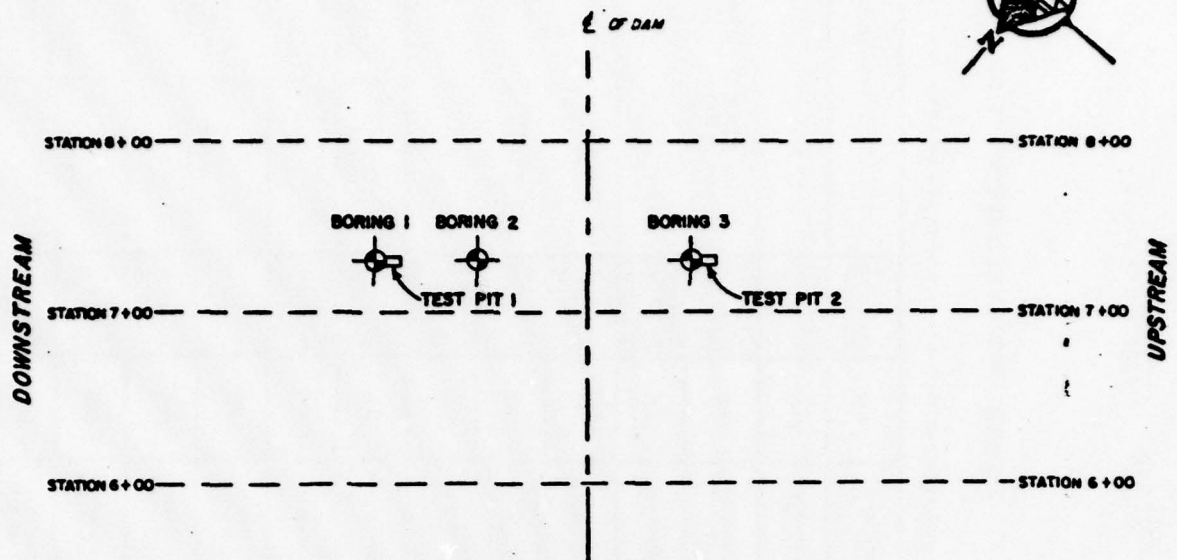
DAMES & MOORE

William G. Paratore

William G. Paratore

WGP:MLK:mf

Four Copies Submitted



| BORING 1 | | | | BORING 2 | | | | BORING 3 | | | |
|-------------------------|---------|---|---------|-------------------------|---------|--|---------|-------------------------|---------|--|---------|
| SURFACE ELEVATION 273.2 | | | | SURFACE ELEVATION 273.8 | | | | SURFACE ELEVATION 285.9 | | | |
| DEPTH IN FEET | SYMBOLS | DESCRIPTIONS | SAMPLES | DEPTH IN FEET | SYMBOLS | DESCRIPTIONS | SAMPLES | DEPTH IN FEET | SYMBOLS | DESCRIPTIONS | SAMPLES |
| 0 | | | | 0 | | | | 0 | | | |
| 5 | ML | REDDISH-BROWN SANDY SILT WITH SOME CLAY AND GRAVEL - FILL | | 5 | ML | REDDISH-BROWN SANDY SILT WITH SOME CLAY AND GRAVEL - FILL | | 5 | ML | BROWN AND REDDISH-BROWN SANDY SILT WITH SOME CLAY AND GRAVEL | |
| 10 | ML | END OF FILL GRAY SANDY SILT WITH CLAY (DECOMPOSED ROCK) | | 10 | SM | END OF FILL GRAY SILTY FINE TO COARSE SAND AND GRAVEL | | 10 | | GRADING MORE GRAVEL | |
| 15 | | BORING COMPLETED AT 12.5' ON 5/12/67 NO WATER ENCOUNTERED | | 15 | | BORING COMPLETED AT 12.5' ON 5/12/67 WATER LEVEL AT 13' ON 5/12/67 | | 15 | | | |
| 20 | | | | 20 | | | | 20 | SM | END OF FILL BROWN AND GRAY SILTY FINE TO MEDIUM SAND | |
| 25 | | | | 25 | | | | 25 | | GRADING GRAY AND COARSER | |
| | | | | | | | | | | BORING COMPLETED AT 24.0' ON 5/12/67 WATER LEVEL AT 20.0' ON 5/12/67 | |

LOG OF BORINGS

NOTES:

ELEVATIONS REFER TO U.S.G.S. DATUM.
ALL SOILS WERE CLASSIFIED IN ACCORDANCE WITH THE UNIFIED SOIL CLASSIFICATION SYSTEM.
ALL SAMPLES WERE OBTAINED BY PUSHING HYDRAULICALLY A DAMES & MOORE SOIL SAMPLER TYPE U WITH A THIN-WALLED SAMPLING TUBE.

| | | | | |
|---|--|--|----|---|
| GRAVEL AND COARSELY SANDY SOILS | CLEAN GRAVELS (LITTLE OR NO FINES) | | GW | ALL-GRADED GRAVELS, GRAVELLY SAND MIXTURES, LITTLE OR NO FINES |
| | GRAVELS WITH FINES (APPROXIMATE AMOUNT OF FINES) | | GP | POORLY-GRADED SANDS, GRAVELLY SAND MIXTURES, LITTLE OR NO FINES |
| MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 40 SIEVE | GRAVELS WITH FINES (APPROXIMATE AMOUNT OF FINES) | | GM | SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES |
| | GRAVELS WITH FINES (APPROXIMATE AMOUNT OF FINES) | | GC | CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES |
| SAND AND SANDY SOILS | CLEAN SAND (LITTLE OR NO FINES) | | SW | WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES |
| | CLEAN SAND (LITTLE OR NO FINES) | | SP | POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES |
| MORE THAN 50% OF COARSE FRACTION PASSING NO. 40 SIEVE | SANDS WITH FINES (APPROXIMATE AMOUNT OF FINES) | | SM | SILTY SANDS, SAND-SILT MIXTURES |
| | SANDS WITH FINES (APPROXIMATE AMOUNT OF FINES) | | SC | CLAYEY SANDS, SAND-CLAY MIXTURES |
| SILTS AND CLAYS | LIQUID LIMIT LESS THAN 50 | | ML | INORGANIC SILTS AND VERY FINE SANDS, SILTY CLAYS, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY |
| | LIQUID LIMIT LESS THAN 50 | | CL | INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, CLEAN CLAYS |
| SILTS AND CLAYS | LIQUID LIMIT LESS THAN 50 | | OL | ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY |
| | LIQUID LIMIT LESS THAN 50 | | MH | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS |
| SILTS AND CLAYS | LIQUID LIMIT LESS THAN 50 | | CH | INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS |
| | LIQUID LIMIT LESS THAN 50 | | OH | ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS |
| ONLY ORGANIC SOILS | | | PT | PEAT, MUDS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS |

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

SOIL CLASSIFICATION CHART

UNIFIED SOIL CLASSIFICATION SYSTEM

TEST METHOD: MEASURE IN POUNDS PER SQUARE FOOT (FROM MOISTURE CONTENT) FOR GRAVITY RATE METHOD (EXPOSED AS A PERCENTAGE OF THE 100 GRAM OF SOIL) OR DENSITY EXPRESSED IN POUNDS PER CUBIC FOOT

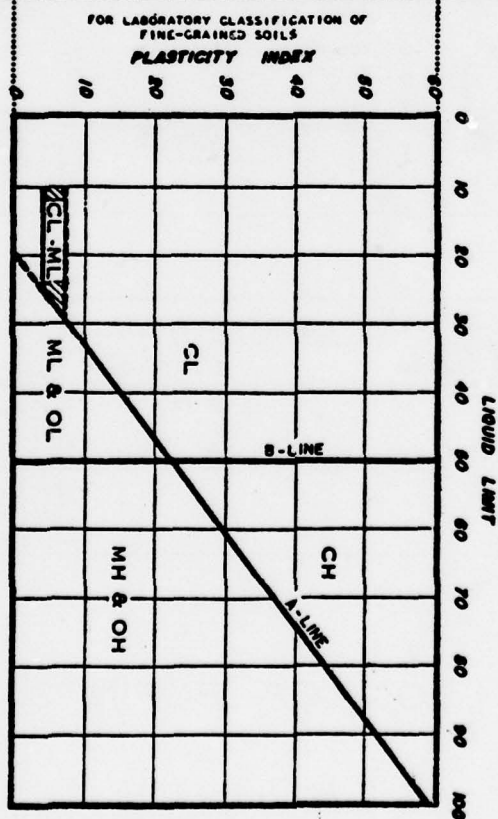
ROCK COMPRESSION TESTS

COMPRESSIVE STRENGTH IN POUNDS PER SQUARE INCH

KEY TO TEST DATA

- INDICATES DEPTH OF UNDISTURBED SAMPLE
- INDICATES DEPTH OF DISTURBED SAMPLE
- INDICATES DEPTH OF SAMPLE ATTEMPT WITH NO RECOVERY
- △ INDICATES DEPTH OF 3/4"-SPOON SAMPLE
- I INDICATES DEPTH AND LENGTH OF CORING RUN

KEY TO SAMPLES



ATTACHMENT A
TRIAXIAL COMPRESSION TESTS
CONSOLIDATED - UNDRAINED
SATURATED

OWNER Baker-Fogel Co LOCATION Orange County BORING # 1
 SOIL TYPE Red Brown & Yellow Sandy clayey silt, trace of decomposed shale (ML-Fill) DEPTH 3.0
 SAMPLE # 23
 SAMPLED 4/8/67 SET-UP 5/19/67 TESTED 5/21/67 (SE OFFICE)

SATURATED TEST 8 FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 2250 PSF

TYPE OF TEST R/CU

| | BEFORE | AFTER |
|---------------------------|--------|-------|
| Weight soil & dish no. | 368 | 219.2 |
| Dry weight soil & dish | 712 | 175.3 |
| Net loss of moisture | 156 | 42.9 |
| Weight of dish only | | |
| Net weight of dry soil | | |
| Moisture, % of dry weight | 21.9 | 24.5 |

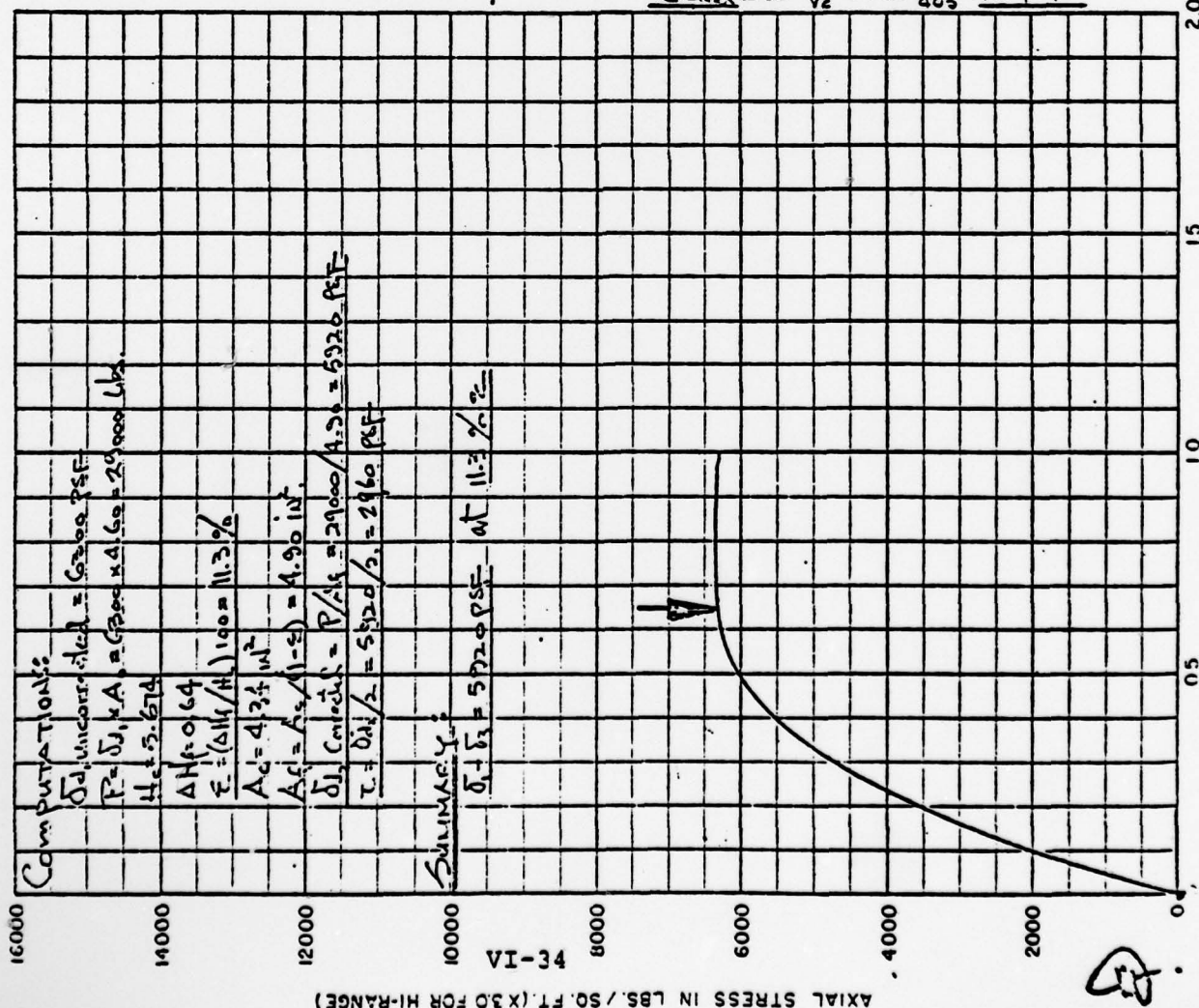


SR = 0.005"/min

Net diameter D_o 2.42 in.
 Area $(0.785 D_o^2)$ A_o 4.60 sq.in.
 Height H_o 5.5 in.
 Volume $(A_o H_o) + 1728$ V_o cu.ft.
 Volume $(A_o H_o) \times 16.4$ V_o 437 cc
 Specific gravity of solids G_s 2.65
 Volume of solids $W_s + G_s$ V_s cc
 $(V_o - V_s) + V_s$ e_i 0.75
 Initial burette reading cc
 Burette reading under pressure cc

Wt. solids + moisture W_o 368 gms. 326
 $W_o + 454$ W_o lbs.
 Weight solids W_s gms.
 Wet density $W_o + V_o$ pcf 127
 Dry density pcf 102

$$\gamma_{d, \text{cal}} = \gamma_d \frac{V_o}{V_c} = 102 \frac{437}{403} = 110 \text{ pcf}$$



BORING: 1 SAMPLE NO.: 2B DEPTH (FT): 3.0 TYPE OF TEST: $\frac{1}{2}$ cu

| SATURATION DATA | | | | | | | | CONSOLIDATION DATA | |
|-----------------|-----------------|------------------|-----------------------|-------------------------|---------------------|----------|-----|--------------------|----------------------------|
| TIME DATE | CHAMBER (PSI) | RACK PRESS (PSI) | EXTERNAL BURETTE (CC) | SATURATION BURETTE (CC) | PORE PRESSURE (PSI) | Δ | B | ELAPSED TIME MIN. | INTERIOR VOL. BURETTE (CC) |
| 2/19/57 | | | | | | | | | |
| 1730 | 25.0 | 22.0 | - | - | 22.0 | - | - | | |
| 1900 | 30.0 | CL. 25.0 | - | - | 22.0/24.1 | 2.1 | .22 | | |
| 1920 | 40.0 | 37.0 | - | - | 37.0 | - | - | | |
| 2/20/57 | | | | | | | | | |
| 1300 | 45.0 | CL. 37.0 | - | - | 37.0/41.2 | 4.2 | .81 | | |
| 1320 | 40.0 | 37.0 | - | - | 37.0 | - | - | | |
| 1600 | 45.0 | CL. 37.0 | - | - | 37.0/41.2 | 4.2 | .81 | | |
| Consolidation | | | | | | | | | |
| 1530 | 2250 = 13.6 psi | 0 | - | - | - | - | - | 0 | 109.0 |
| | | | | | | | | .1 | 111.6 |
| | | | | | | | | .25 | 112.5 |
| | | | | | | | | .5 | 113.4 |
| 1531 | | | | | | | | 1 | 115.0 |
| 1532 | | | | | | | | 2 | 116.7 |
| 1534 | | | | | | | | 4 | 119.1 |
| 1539 | | | | | | | | 8.9 | 123.0 |
| 1546 | | | | | | | | 16 | 125.2 |
| 1600 | | | | | | | | 30 | 128.7 |
| 1630 | | | | | | | | 60 | 133.6 |
| 1730 | | | | | | | | 120 | 135.4 |
| 1830 | | | | | | | | 240 | 132.6 |
| 12330 | | | | | | | | 480 | - |
| 2/1530 | | | | | | | | 1440 | 143.3 |

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_0)..... 5.800 IN.
 INITIAL DIAL: 0.000 FINAL DIAL: 0.126, CHANGE IN HEIGHT (ΔH):... 0.126 IN.
 SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)..... 5.674 IN.
 PERCENTS DEFLECTION. (E)..... 2.2 %

ORIGINAL SAMPLE VOLUME (V_0)..... 437 CC.
 INITIAL BURETTE: 109.0 FINAL BURETTE: 143.0, CHANGE IN VOLUME (ΔV)... 34 CC.
 SAMPLE VOLUME AFTER CONSOLIDATION (V_c)..... 403 CC.

ORIGINAL SAMPLE AREA (A_0)..... 4.60 IN².
 AREA CORRECTION:

$$\begin{aligned}
 A_c &= A_0 (1 - \Delta V / V_0 / 1 - E) \\
 &= 4.60 (1 - 34 / 437 / 1 - 0.022) \\
 &= 4.60 (0.922 / 0.978) \\
 &= 4.34 \text{ SQ. IN.}
 \end{aligned}$$

(Signature)

TRIAxIAL COMPRESSION TEST DATA SHEET

JOB # 5631-003-07

OWNER BAUER EVOK CO LOCATION ORANGE COUNTY BORING # 1 *

SOIL TYPE Red & Brown clayey sandy silt with some gravel DEPTH 60'

SAMPLE # 3A

SAMPLED JAN 5/12/67 SET-UP SW 5/19/67 TESTED SW 5/23/67 (SF OFFICE)

SATURATED TEST X FIELD MOISTURE TEST — TEST LATERAL PRESSURE 3000 PSF

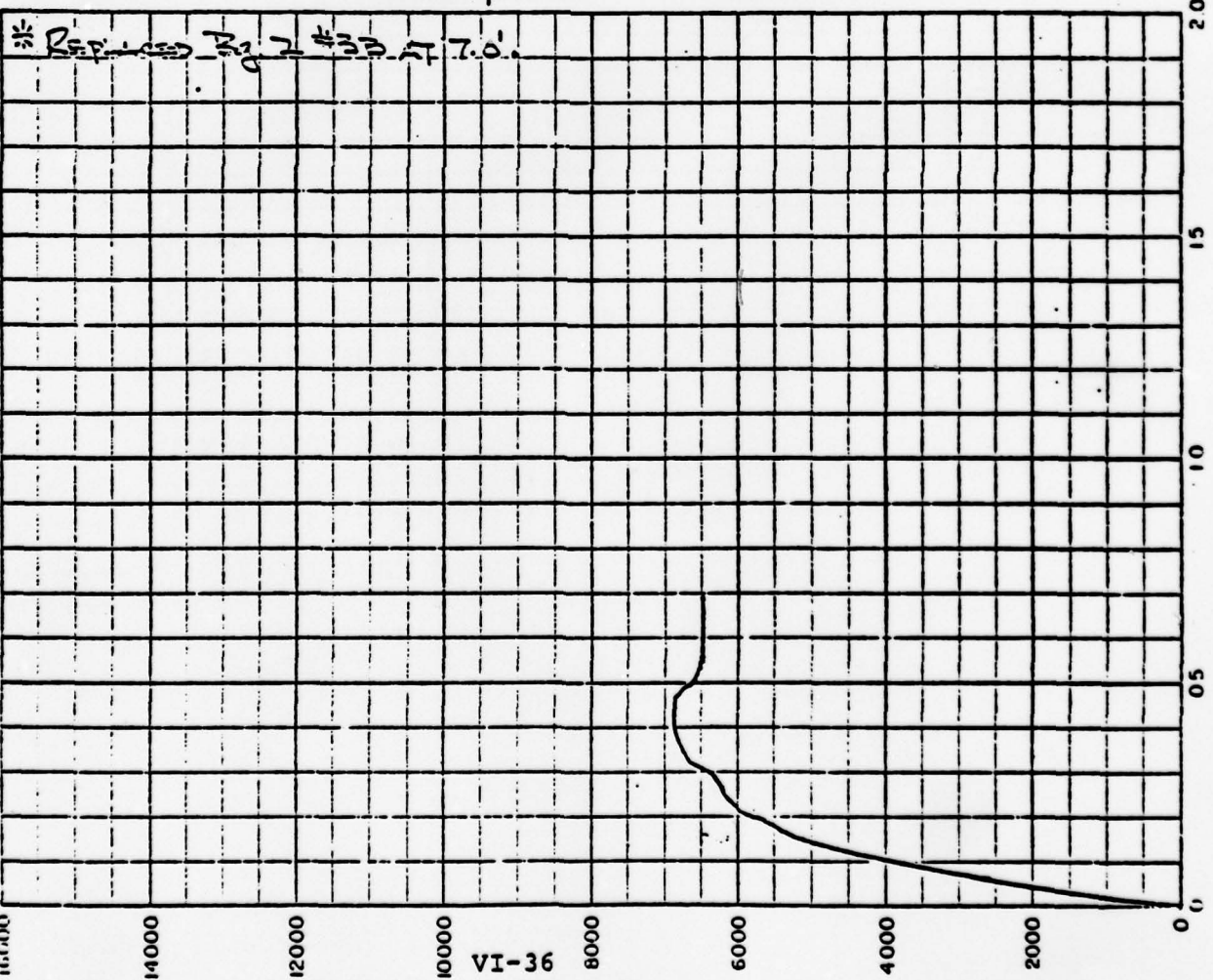
TYPE OF TEST IX/CN BEFORE AFTER

Weight soil & dish no. 842 269.6
 Dry weight soil & dish 697 234.4
 Net loss of moisture 145 55.2
 Weight of dish only —
 Net weight of dry soil —
 Moisture, % of dry weight 20.8 23.5

Wt. solids + moisture W_o 842 gms. 362
 $W_o + 454$ W_o' — lbs. —
 Weight solids W_s — gms. —
 Wet density $W_o' + V_o'$ 125 pcf 123
 Dry density 104 pcf 104



Net diameter D_o 2.42 in.
 Area $(0.785 D_o^2)$ A_o 4.60 sq.in.
 Height H_o 5.6 in.
 Volume $(A_o H_o) + 1728$ V_o' — cu.ft.
 Volume $(A_o H_o) + 16.4$ V_o 430 cc
 Specific gravity of solids G_s —
 Volume of solids $W_s + G_s$ V_s — cc
 $(V_o - V_s) + V_s$ e_i —
 Initial burette reading — cc
 Burette reading under pressure — cc
 $(V_p - V_s) + V_s$ e_p —



BORING: 2 SAMPLE NO.: 33 DEPTH (FT): 7.5 TYPE OF TEST: σ_c/σ_h

| SATURATION DATA | | | | | | | | CONSOLIDATION DATA | |
|-----------------|------------------------------|------------------------------------|-----------------------------|-------------------------------|---------------------------|----------|-----|----------------------|-------------------------------|
| TIME DATE | σ CHAMBER (PSI) | σ BACK PRESS (PSI) | EXTERNAL BURETTE (CC) | SATURATION BURETTE (CC) | PORE PRESSURE (PSI) | Δ | B | ELAPSED TIME MIN. | INTERIOR VOL. BURETTE (CC) |
| 10:00 | 3 | 0 | Saturating | Saturating | - | - | - | | |
| 10:20 | 30 | 27 | - | - | 27.0 | - | - | | |
| 10:50 | 25 | 25.0 | - | - | 27.0 / 31.0 | 4.0 | .85 | | |
| 11:20 | 30 | 27 | - | - | 27.0 | - | - | | |
| 11:22/30 | | | | | | | | | |
| 11:00 | 35 | 35.0 | - | - | 27.0 / 31.8 | 4.8 | .96 | | |
| | | | Consolidation | | | | | | |
| 11:30 | 3-12-20.8 | 0 | - | - | - | - | - | 0 | 136.0 |
| 1 | | | | | | | | .1 | 137.5 |
| 1 | | | | | | | | .25 | 138.2 |
| 1 | | | | | | | | .5 | 138.7 |
| 11:31 | | | | | | | | 1 | 139.5 |
| 11:32 | | | | | | | | 2 | 140.2 |
| 11:34 | | | | | | | | 4 | 141.0 |
| 11:35 | | | | | | | | 8.5 | 142.0 |
| 11:40 | | | | | | | | 16 | 143.0 |
| 12:00 | | | | | | | | 30 | 144.5 |
| 12:30 | | | | | | | | 60 | 146.0 |
| 12:50 | | | | | | | | 120 | 148.0 |
| 13:00 | | | | | | | | 240 | 150.0 |
| 13:30 | | | | | | | | 480 | 161.0 |
| 13:50 | | | | | | | | 1440 | 162.5 |

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_0)..... 5.600 IN.
 INITIAL DIAL: 0.000 FINAL DIAL: 0.075, CHANGE IN HEIGHT (ΔH):... .075 IN.
 SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)..... 5.525 IN.
 PERCENTS DEFLECTION. (E)..... %

ORIGINAL SAMPLE VOLUME (V_0)..... 430.0 CC.
 INITIAL BURETTE: 135.0 FINAL BURETTE: 162.5, CHANGE IN VOLUME (ΔV)... 27.5 CC.
 SAMPLE VOLUME AFTER CONSOLIDATION (V_c)..... 402.5 CC.

ORIGINAL SAMPLE AREA (A_0)..... 4.60 IN².
 AREA CORRECTION:

$$A_c = A_0 (1 - \Delta V / V_0 / 1 - E)$$

= _____
 = _____
 = _____ SQ. IN.

OWNER BAUER EUGENE Co LOCATION ORANGE COUNTY BORING # 2
 SOIL TYPE Red brown very clayey sandy silt with DEPTH 1.5'
Some gravel (N.L. - FILL) SAMPLE # 13

SAMPLED JBR 5/12/67 SET-UP SM 5/21/67 TESTED SM 5/23/67 (SE OFFICE)

SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 4500 PSF

TYPE OF TEST TC/CU

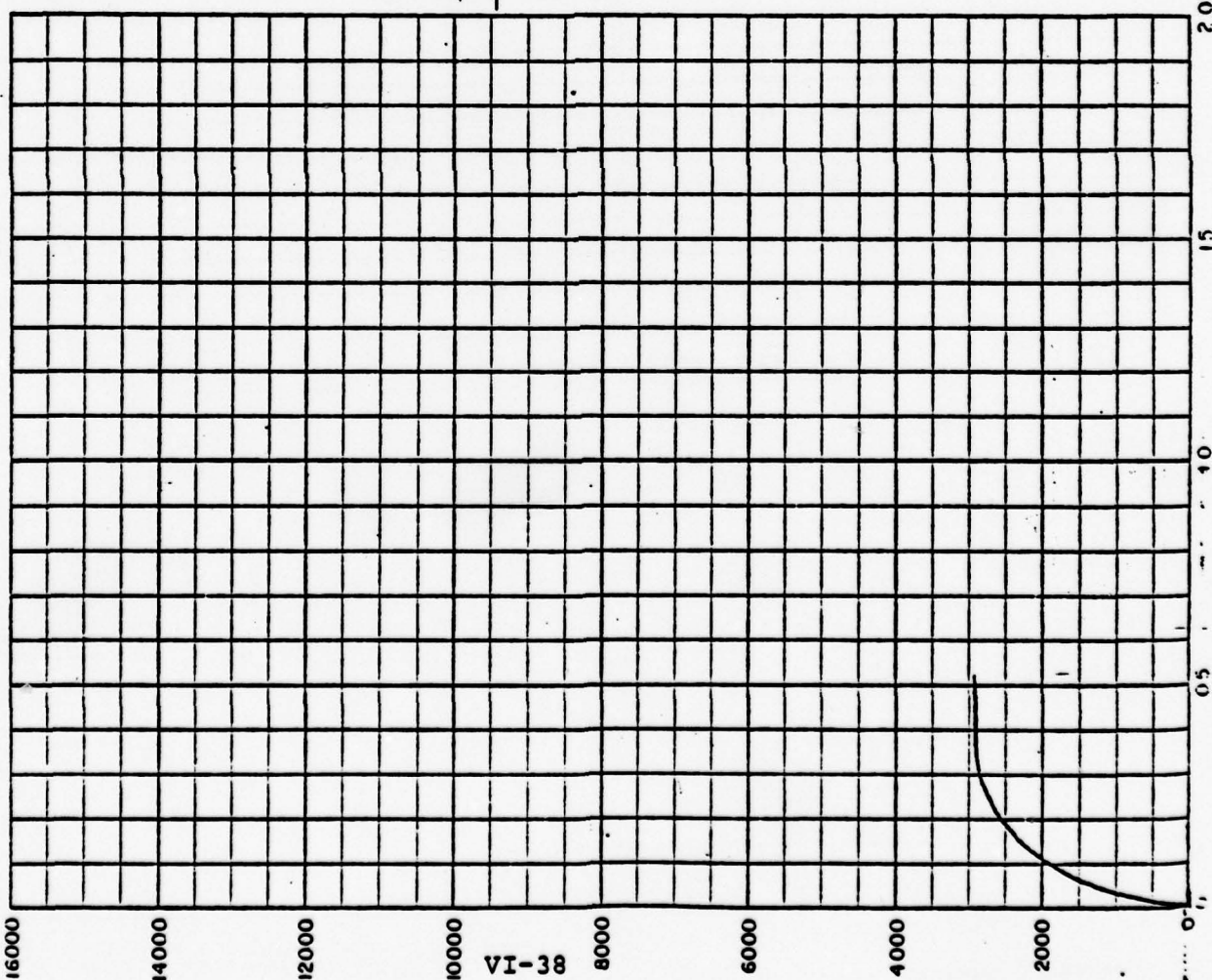
Weight soil & dish no. 361 316.2
 Dry weight soil & dish 687 247.7
 Net loss of moisture 174 68.5
 Weight of dish only _____
 Net weight of dry soil _____
 Moisture, % of dry weight 25.4 27.7

Wt. solids + moisture W_o 861 gms. 876
 $W_o + 454$ W'_o _____ lbs.
 Weight solids W_s _____ gms.
 Wet density $W'_o + V'_o$ 119 pcf 122
 Dry density 95.4 pcf 95.4



SOFT ZONE

Net diameter D_o 2.42 in.
 Area $(0.785 D_o^2)$ A_o 4.60 sq.in.
 Height H_o 6.0 in.
 Volume $(A_o H_o) + 1728$ V'_o _____ cu.ft.
 Volume $(A_o H_o) + 16.4$ V_o 453 cc
 Specific gravity of solids G_s _____
 Volume of solids $W_s + G_s$ V_s _____ cc
 $(V_o - V_s) + V_s$ e_i _____
 Initial burette reading _____ cc
 Burette reading under pressure _____ cc
 $(V_p - V_s) + V_s$ e_p _____



AXIAL STRESS IN LBS. / SQ. FT. (X 3.0 FOR HI-RANGE)

| SATURATION DATA | | | | | | | | CONSOLIDATION DATA | |
|-----------------|------------------|------------------------|-----------------------------|-------------------------------|---------------------------|----------|------|----------------------|-------------------------------|
| TIME DATE | CHAMBER (PSI) | BACK PRESS (PSI) | EXTERNAL BURETTE (CC) | SATURATION BURETTE (CC) | PORE PRESSURE (PSI) | Δ | B | ELAPSED TIME MIN. | INTERIOR VOL. BURETTE (CC) |
| 2/21/65 | 5.0 | 0 | 5.0 | 5.0 | 0 | 0 | 0 | | |
| 1150 | 35.0 | 30 | 5.0 | 5.0 | 30.0 | 0 | 0 | | |
| 1230 | 40.0 | 30 | 5.0 | 5.0 | 30.0/21.1 | 4.1 | .82 | | |
| 1300 | 35.0 | 30 | 5.0 | 5.0 | 30.0 | 0 | 0 | | |
| 1500 | 40.0 | 30 | 5.0 | 5.0 | 30.0/31.8 | 1.8 | .45 | | |
| 1530 | 35.0 | 30 | 5.0 | 5.0 | 30.0 | 0 | 0 | | |
| 1700 | 30.0 | 30 | 5.0 | 5.0 | 30.0/34.8 | 4.8 | .96 | | |
| 1730 | | | | | | | | | |
| 1730 | 45.0 | 0 | | | | 70.0 | 50.0 | 0 | 0 |
| | | | | | | 72.0 | 45.0 | .1 | |
| | | | | | | 71.8 | 45.0 | .25 | |
| | | | | | | 71.2 | 44.4 | .5 | |
| | | | | | | 70.9 | 44.0 | 1 | |
| 1751 | | | | | | 70.8 | 44.0 | 2 | |
| 1752 | | | | | | 68.7 | 42.2 | 4 | |
| 1754 | | | | | | 67.2 | 42.2 | 8 | |
| 1757 | | | | | | 65.8 | 42.6 | 12 | |
| 1758 | | | | | | 64.4 | 41.7 | 16 | |
| 1800 | | | | | | 63.6 | 41.4 | 30 | |
| 1830 | | | | | | 62.7 | 41.6 | 60 | |
| 1830 | | | | | | 62.3 | 41.2 | 120 | |
| 2130 | | | | | | 62.0 | 41.8 | 240 | |
| | | | | | | | | 480 | |
| 2/22 1730 | | | | | | 61.8 | 42.8 | 1440 | |

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_0)..... 6.000 IN.
 INITIAL DIAL: 0.500 FINAL DIAL: 0.054, CHANGE IN HEIGHT (ΔH):.. 0.054 IN.
 SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)..... 5.946 IN.
 PERCENTS DEFLECTION. (E)..... %

ORIGINAL SAMPLE VOLUME (V_0)..... 453.0 CC.
 INITIAL BURETTE: 117.0 FINAL BURETTE: 92.3, CHANGE IN VOLUME (ΔV)... 24.7 CC.
 SAMPLE VOLUME AFTER CONSOLIDATION (V_c)..... 428.3 CC.

ORIGINAL SAMPLE AREA (A_0)..... 4.60 IN².
 AREA CORRECTION:

$$A_c = A_0 (1 - \Delta V / V_0 / 1 - E)$$

= _____
 = _____
 = _____ SQ. IN.

JOB # 5631-003-07OWNER BAVER FAVOR CO. LOCATION ORANGE COUNTY BORING # 2SOIL TYPE Red & yellow clayey sandy silt. with DEPTH 4.5SEATER GRAVELS (ML-FILL) SAMPLE # 2ASAMPLED 5/12/67 SET-UP 5/19/67 TESTED 5/22/67 (SE OFFICE)SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 1000 PSFTYPE OF TEST DC/CUWeight soil & dish no. 924 267Dry weight soil & dish 781 214.4Net loss of moisture 143 50.2

Weight of dish only _____

Net weight of dry soil _____

Moisture, % of dry weight _____

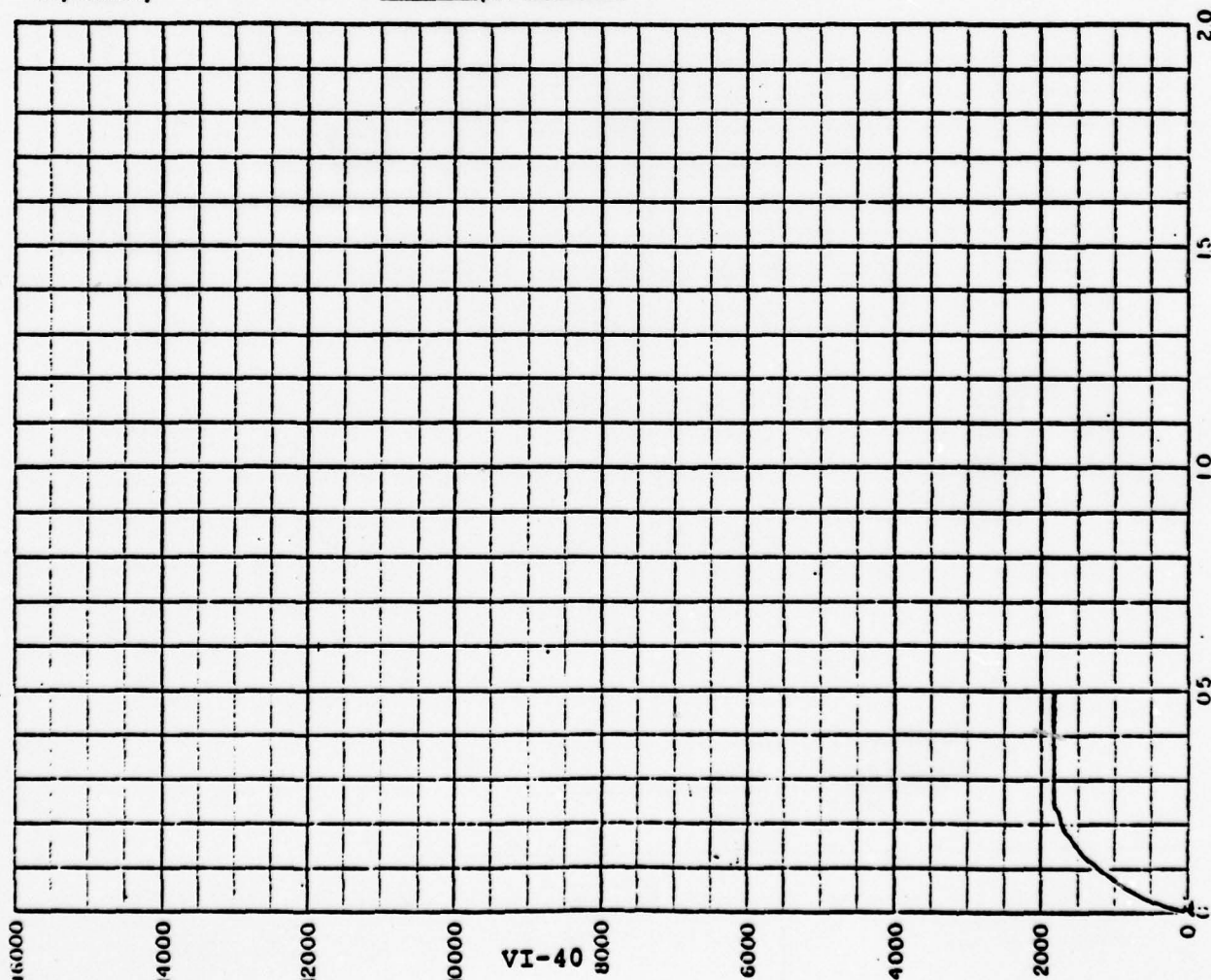
Wt. solids + moisture 924 gms. 964 $W_o = 454$ 781 lbs.Weight solids 781 gms.Wet density $W_o' + V_o'$ 129 pcf 131

Dry density _____ pcf _____

Net diameter 2.42 in.Area ($0.785 D_o^2$) 4.60 sq. in.Height 6.0 in.Volume ($A_o H_o$) + 1728 453 cu. ft.Volume ($A_o H_o$) x 16.4 453 ccSpecific gravity of solids G_sVolume of solids $W_s + G_s$ V_s cc $(V_o - V_s) + V_s$ e_i

Initial burette reading _____ cc

Burette reading under pressure _____ cc

 $(V_p - V_s) + V_s$ e_p

| SATURATION DATA | | | | | | | | CONSOLIDATION DATA | |
|-----------------|---------------|------------------|-----------------------|-------------------------|---------------------|----------|-----|--------------------|----------------------------|
| TIME DATE | CHAMBER (PSI) | BACK PRESS (PSI) | EXTERNAL BURETTE (CC) | SATURATION BURETTE (CC) | PORE PRESSURE (PSI) | Δ | B | ELAPSED TIME MIN. | INTERIOR VOL. BURETTE (CC) |
| 3/12/50 | 3.0 | 0 | Seepage | Seepage | - | - | - | | |
| 3/20/50 | | | | | | | | | |
| 1750 | 30 | 27 | - | - | 27.0 | - | - | | |
| 12000 | 30 | 27 | - | - | 27.0 / 31.2 | 4.2 | .98 | | |
| 2020 | 30 | 27 | - | - | 27.0 | - | - | | |
| 3/21/50 | | | | | | | | | |
| 1200 | 30 | 27 | - | - | 27.0 / 31.7 | 4.7 | .94 | | |
| | | | | | | | | | |
| | | | (CONSOLIDATION) | | | | | | |
| 1230 | 30 | 27 | - | - | | | | 0 | 100.0 |
| 1 | | | | | | | | .1 | 100.0 |
| 1 | | | | | | | | .25 | 100.0 |
| 1 | | | | | | | | .5 | 100.0 |
| 1231 | | | | | | | | 1 | 100.0 |
| 1232 | | | | | | | | 2 | 100.0 |
| 1234 | | | | | | | | 4 | 100.0 |
| 1239 | | | | | | | | 8-9 | - |
| 1246 | | | | | | | | 16 | - |
| 1200 | | | | | | | | 30 | 100.0 |
| 1330 | | | | | | | | 60 | 100.0 |
| 1530 | | | | | | | | 120 | 100.0 |
| 1630 | | | | | | | | 240 | 100.0 |
| 1700 | | | | | | | | 480 | - |
| 3/22/50 | | | | | | | | 1440 | 162.0 |

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_0)..... 6.000 IN.
 INITIAL DIAL: 2.000 FINAL DIAL: 0.042, CHANGE IN HEIGHT (ΔH):... 0.042 IN.
 SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)..... 5.958 IN.
 PERCENTS DEFLECTION. (E)..... 0.70 %
 ORIGINAL SAMPLE VOLUME (V_0)..... 453.0 CC.
 INITIAL BURETTE: 16.3 FINAL BURETTE: 1.3, CHANGE IN VOLUME (ΔV):... 18.3 CC.
 SAMPLE VOLUME AFTER CONSOLIDATION (V_c)..... 434.7 CC.
 ORIGINAL SAMPLE AREA (A_0)..... 4.60 IN.
 AREA CORRECTION:

$$A_c = A_0 (1 - \Delta V / V_0 / 1 - E)$$

= _____

= _____

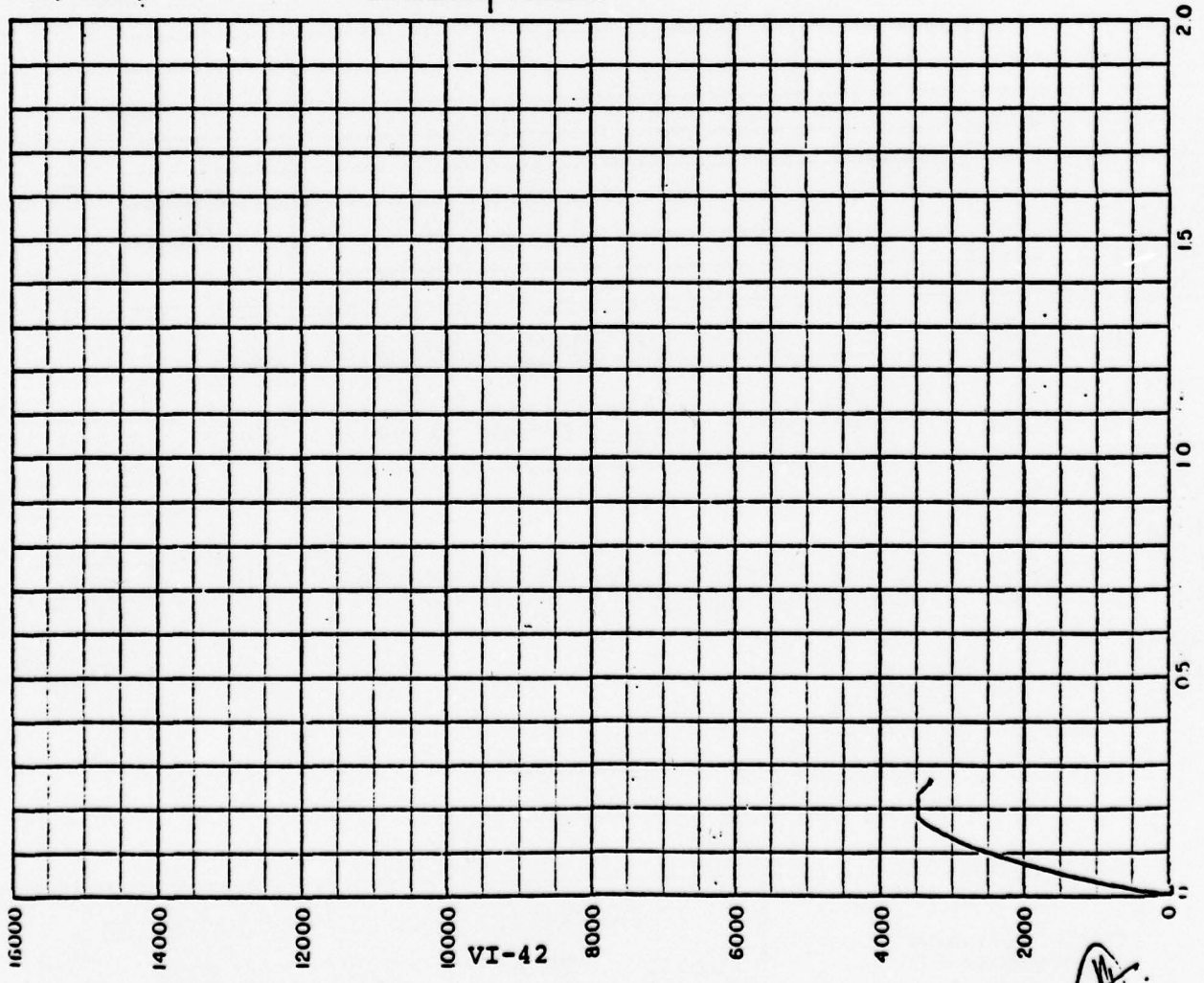
= _____ SQ. IN.

OWNER Baker Sugar Co LOCATION Orange County BORING # 3
 SOIL TYPE Yellow & Brown Sandy clayey silt DEPTH 1.5'
with gravel & shale fragment (ML - Fill) SAMPLE # 13
 SAMPLED 5/12/67 SET-UP 5/22/67 TESTED 5/24/67 (SF OFFICE)
 SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 1500 PSF

TYPE OF TEST TS/CU
 Weight soil & dish no. 933 106
 Dry weight soil & dish 906 241.4
 Net loss of moisture 127 45.3
 Weight of dish only _____
 Net weight of dry soil _____
 Moisture, % of dry weight 15.8 18.8
 Wt. solids + moisture W₀ 933 gms. 955
W₀ + 454 W₀ lbs.
 Weight solids W_s gms.
 Wet density W₀ + V₀ 131 pcf 134
 Dry density 113 pcf 113



Net diameter D₀ 2.42 in.
 Area A₀ 4.60 sq.in.
 Height H₀ 5.9 in.
 Volume (A₀H₀) + 1728 V₀ cu.ft.
 Volume (A₀H₀) = 16.4 V₀ 445 cc
 Specific gravity of solids G_s _____
 Volume of solids W_s + G_s V_s cc
(V₀ - V_s) + V_s e_i _____
 Initial burette reading _____ cc
 Burette reading under pressure _____ cc
(V_p - V_s) + V_s e_p _____



VI-42

BORING: 3 SAMPLE NO.: 13 DEPTH (FT): 1.5 TYPE OF TEST: CU

| SATURATION DATA | | | | | | | | CONSOLIDATION DATA | |
|--------------------|---------------|------------------|-----------------------|-------------------------|---------------------|----------|-----|--------------------|----------------------------|
| TIME DATE | CHAMBER (PSI) | BACK PRESS (PSI) | EXTERNAL BURETTE (CC) | SATURATION BURETTE (CC) | PORE PRESSURE (PSI) | Δ | B | ELAPSED TIME MIN. | INTERIOR VOL. BURETTE (CC) |
| 11/2/61 | 32.0 | 25.0 | - | - | 25.0 | - | - | | |
| 11/2/61 | 32.0 | 25.0 | - | - | 25.0 | 28.5 | 2.5 | 1.5 | |
| 11/2/61 | 32.0 | 25.0 | - | - | 25.0 | - | - | | |
| 11/2/61 | 32.0 | 25.0 | - | - | 25.0 | - | - | | |
| 12/2/61 | 35.0 | 25.0 | - | - | 25.0 | 29.5 | 4.5 | .96 | |
| 12/2/61 | 35.0 | 25.0 | - | - | 25.0 | - | - | | |
| 12/2/61 | 35.0 | 25.0 | - | - | 25.0 | 21.9 | 4.9 | .78 | |
| Consolidation Time | | | | | | | | | |
| 1500 | 1500 psi | 0 | - | - | - | - | - | 0 | 144.0 |
| | | | | | | | | .1 | |
| | | | | | | | | .25 | |
| | | | | | | | | .5 | |
| | | | | | | | | 1 | |
| | | | | | | | | 2 | |
| | | | | | | | | 4 | |
| | | | | | | | | 8 | |
| | | | | | | | | 16 | |
| | | | | | | | | 30 | |
| | | | | | | | | 60 | |
| 1500 | | | | | | | | 120 | 155.0 |
| | | | | | | | | 240 | |
| 5/25/61 | | | | | | | | 480 | |
| 1800 | | | | | | | | 1440 | 156.6 |

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_0)..... 5.900 IN.
 INITIAL DIAL: 0.000 FINAL DIAL: 0.046, CHANGE IN HEIGHT (ΔH):... 0.046 IN.
 SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)..... 5.854 IN.
 PERCENTS DEFLECTION. (E)..... %

ORIGINAL SAMPLE VOLUME (V_0)..... 445.0 CC.
 INITIAL BURETTE: 144.0 FINAL BURETTE: 158.6, CHANGE IN VOLUME (ΔV)... 14.6 CC.
 SAMPLE VOLUME AFTER CONSOLIDATION (V_c)..... 430.4 CC.

ORIGINAL SAMPLE AREA (A_0)..... 1.60 IN².
 AREA CORRECTION:

$$A_c = A_0 (1 - \Delta V / V_0 / 1 - E)$$

= _____
 = _____
 = _____ SQ. IN.

[Signature]

JOB # 2551-025-01

OWNER Bayer Soil Co LOCATION Orange County BORING # 3
 SOIL TYPE Yellow-Brown Sandy C.H. with Decomposed DEPTH 3.0'
State & Trace of Gravel (UL-Fill) SAMPLE # 23

SAMPLED JBL 5/23/67 SET-UP SW 5/23/67 TESTED SW 5/23/67 (SF OFFICE)

SATURATED TEST ☒ 2500 FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 2000 PSF

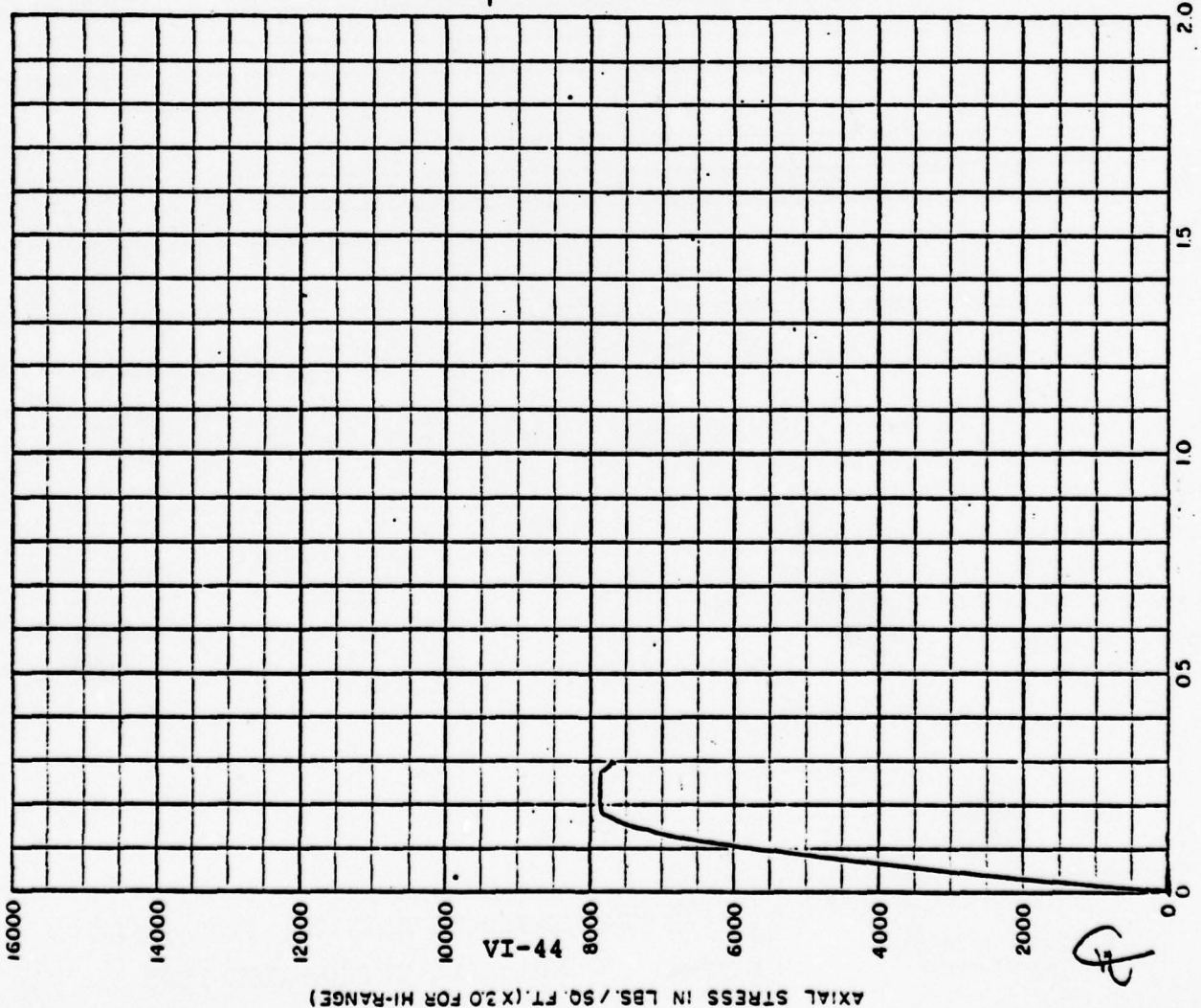
TYPE OF TEST Tx/cu

| | | |
|---------------------------|--------------|--------------|
| Weight soil & dish no. | <u>9220</u> | <u>213.1</u> |
| Dry weight soil & dish | <u>811.0</u> | <u>182.1</u> |
| Net loss of moisture | <u>121.0</u> | <u>31.0</u> |
| Weight of dish only | | |
| Net weight of dry soil | | |
| Moisture, % of dry weight | <u>14.9</u> | <u>17.1</u> |



| | | |
|---|--------------------------|-----------------|
| Wt. solids + moisture | <u>W₀ 932</u> | <u>gms. 951</u> |
| W ₀ + 454 | <u>W₀</u> | <u>lbs.</u> |
| Weight solids | <u>W_s</u> | <u>gms.</u> |
| Wet density W ₀ + V ₀ | <u>131</u> | <u>pcf 136</u> |
| Dry density | <u>114</u> | <u>pcf 114</u> |

| | | |
|---|----------------------------|--------|
| Net diameter | D ₀ <u>2.62</u> | in. |
| Area (0.785 D ₀ ²) | A ₀ <u>4.60</u> | sq.in. |
| Height | H ₀ <u>5.9</u> | in. |
| Volume (A ₀ H ₀) + 1728 | V ₀ | cu.ft. |
| Volume (A ₀ H ₀) × 16.4 | V ₀ | cc |
| Specific gravity of solids | G _s | |
| Volume of solids W _s + G _s | V _s | cc |
| (V ₀ - V _s) + V _s | e _i | |
| Initial burette reading | | cc |
| Burette reading under pressure | | cc |
| (V _p - V _s) + V _s | e _p | |



BORING: 3 SAMPLE NO.: 28 DEPTH (FT): 3.0 TYPE OF TEST:

| SATURATION DATA | | | | | | | | CONSOLIDATION DATA | |
|-----------------|---------------|------------------|-----------------------|-------------------------|---------------------|----------|-----|--------------------|----------------------------|
| TIME DATE | CHAMBER (PSI) | BACK PRESS (PSI) | EXTERNAL BURETTE (CC) | SATURATION BURETTE (CC) | PORE PRESSURE (PSI) | Δ | B | ELAPSED TIME MIN. | INTERIOR VOL. BURETTE (CC) |
| 3/22/54 | 5.0 | 0 | Saturated | | - | - | - | | |
| 3/22/54 | | | | | | | | | |
| 1330 | 30.0 | 25.0 | - | - | 25.0 | - | - | | |
| 1500 | 35.0 | closed | - | - | 25.0 / 27.9 | 2.9 | .58 | | |
| 1530 | 30.0 | 25.0 | - | - | 25.0 | - | - | | |
| 1930 | 35.0 | closed | - | - | 25.0 / 28.6 | 3.6 | .72 | | |
| 1950 | 30.0 | 25.0 | - | - | 25.0 | - | - | | |
| 3/22/54 | 35.0 | closed | - | - | 25.0 / 29.9 | 4.9 | .99 | | |
| | | | Consolidated | | | | | | |
| 1630 | 3000 PBF | 0 | | | | | | 0 | 143.0 |
| | | | | | | | | .1 | 145.5 |
| | | | | | | | | .25 | 145.8 |
| | | | | | | | | .5 | 146.1 |
| | | | | | | | | 1 | 146.3 |
| | | | | | | | | 2 | 146.5 |
| | | | | | | | | 4 | 146.9 |
| | | | | | | | | 8 | |
| | | | | | | | | 16 | |
| | | | | | | | | 30 | 149.0 |
| | | | | | | | | 60 | 148.2 |
| | | | | | | | | 120 | |
| | | | | | | | | 240 | |
| 3/6 | | | | | | | | 480 | |
| 1030 | | | | | | | | 1440 | 157.0 |

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_0)..... 5.900 IN.
 INITIAL DIAL: 0.250 FINAL DIAL: 0.052, CHANGE IN HEIGHT (ΔH):... 0.252 IN.
 SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)..... 5.343 IN.
 PERCENTS DEFLECTION. (E)..... 9

ORIGINAL SAMPLE VOLUME (V_0)..... 445.0 CC.
 INITIAL BURETTE: 143.0 FINAL BURETTE: 157.2, CHANGE IN VOLUME (ΔV)... 14.2 CC.
 SAMPLE VOLUME AFTER CONSOLIDATION (V_c)..... 430.8 CC.

ORIGINAL SAMPLE AREA (A_0)..... 4.60 IN².
 AREA CORRECTION:

$$A_c = A_0 (1 - \Delta V / V_0 / 1 - E)$$

= _____
 = _____
 = _____ SQ. IN.

14

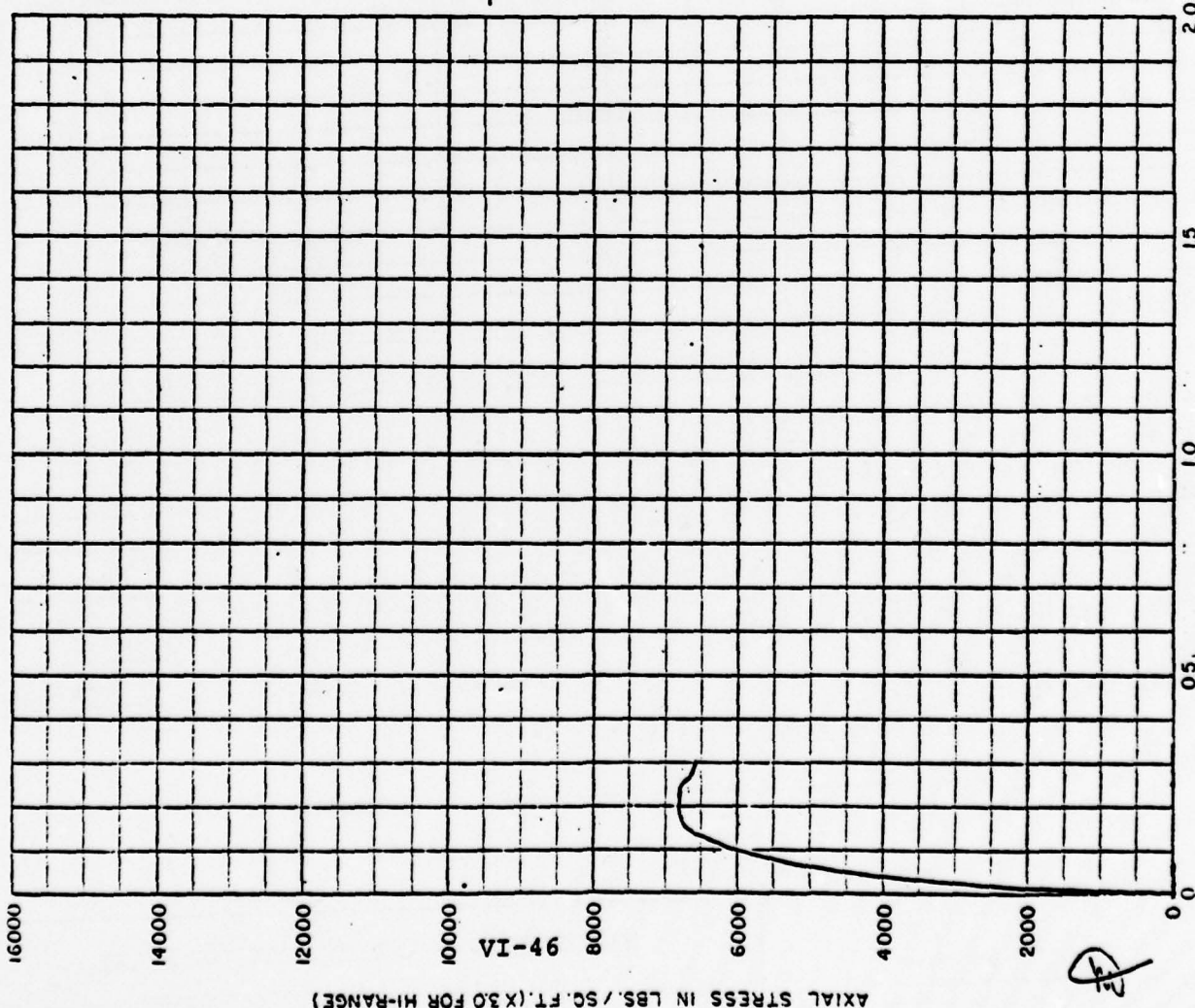
JOB # 5651-003-01
 OWNER BAVER SOIL CO. LOCATION CRADGE COUNTY BORING # 3
 SOIL TYPE Red Gray & brown sandy clay silt DEPTH 9.0
with some gravel (ML-Fine) SAMPLE # 4A
 SAMPLED 5/12/67 SET-UP 5/24/67 TESTED 5/25/67 (SF OFFICE)
 SATURATED TEST ☒ FIELD MOISTURE TEST ☐ TEST LATERAL PRESSURE 400 PSF

TYPE OF TEST TCU

Weight soil & dish no. 929 304.6
 Dry weight soil & dish 776 243.9
 Net loss of moisture 153 54.8
 Weight of dish only _____
 Net weight of dry soil _____
 Moisture, % of dry weight 19.7 22.0

Wt. solids + moisture W_o 929 gms. 947
 $W_o + 454$ W_o' _____ lbs.
 Weight solids W_s _____ gms.
 Wet density $W_o' + V_o'$ 129 pcf 132
 Dry density 108 pcf 108

Net diameter D_o 2.42 in.
 Area $(0.785 D_o^2)$ A_o 4.60 sq.in.
 Height H_o 6.0 in.
 Volume $(A_o H_o) + 1728$ V_o _____ cu.ft.
 Volume $(A_o H_o) + 16.4$ V_o _____ cc
 Specific gravity of solids G_s _____
 Volume of solids $W_s + G_s$ V_s _____ cc
 $(V_o - V_s) + V_s$ e_i _____
 Initial burette reading _____ cc
 Burette reading under pressure _____ cc
 $(V_p - V_s) + V_s$ e_p _____



| SATURATION DATA | | | | | | | | CONSOLI- DATION DATA | |
|-----------------|------------------|------------------------|-----------------------------|-------------------------------|---------------------------|----------|------|----------------------------|-------------------------------|
| TIME DATE | CHAMBER (PSI) | BACK PRESS (PSI) | EXTERNAL BURETTE (CC) | SATURATION BURETTE (CC) | PORE PRESSURE (PSI) | Δ | B | ELAPSED TIME MIN. | INTERIOR VOL. BURETTE (CC) |
| 2:00 | 10.0 | 5.0 | - | - | 5.0 | - | - | | |
| 2:05 | 20.0 | 25.0 | - | - | 25.0 | - | - | | |
| 1:30 | 35.0 | 40.0 | - | - | 25.0 - 28.0 | 3.0 | 0.60 | | |
| 1:40 | 30.0 | 25.0 | - | - | 25.0 | | | | |
| 1:50 | 35.0 | 40.0 | - | - | 25.0 / 28.6 | 3.6 | .72 | | |
| 1:55 | 30.0 | 25.0 | - | - | 25.0 | - | - | | |
| 2:00 | | | | | | | | | |
| 1:100 | 35.0 | 40.0 | - | - | 25.0 / 29.8 | 4.8 | .96 | | |
| 1:100 | 450.0 | 0 | Consolidation | | | | | 0 | 150.0 |
| | | | | | | | | .1 | |
| | | | | | | | | .25 | |
| | | | | | | | | .5 | |
| | | | | | | | | 1 | |
| | | | | | | | | 2 | |
| | | | | | | | | 4 | |
| | | | | | | | | 8 | |
| | | | | | | | | 16 | |
| | | | | | | | | 30 | |
| | | | | | | | | 60 | |
| | | | | | | | | 120 | |
| 1:600 | | | | | | | | 240 | 165.0 |
| 4:30 | | | | | | | | 480 | |
| 1:200 | | | | | | | | 1440 | 193.2 |

SAMPLE HEIGHT, AREA, AND VOLUME CORRECTIONS AFTER CONSOLIDATION

ORIGINAL SAMPLE HEIGHT (H_0)..... 6.000 IN.
INITIAL DIAL: 0.000 FINAL DIAL: 0.057, CHANGE IN HEIGHT (ΔH)... 0.057 IN.
SAMPLE HEIGHT AFTER CONSOLIDATION (H_c)... 5.943 IN.
PERCENTS DEFLECTION. (E)..... %

ORIGINAL SAMPLE VOLUME (V_0)..... 453.0 CC.
INITIAL BURETTE: 150.0 FINAL BURETTE: 168.1, CHANGE IN VOLUME (ΔV)... 18.1 CC.
SAMPLE VOLUME AFTER CONSOLIDATION (V_c)..... 434.9 CC.

ORIGINAL SAMPLE AREA (A_0)..... 4.60 IN².
AREA CORRECTION:

$$A_c = A_0 (1 - \Delta V / V_0 / 1 - E)$$

= _____
= _____
= _____ SQ. IN.

ATTACHMENT B
TRIAxIAL COMPRESSION TESTS
UNCONSOLIDATED - UNDRAINED
FIELD MOISTURE CONTENT

IF HIGH RANGE MODE OF RECORDING DATA IS SET AT BEGINNING OF TEST,
OR IF RECORDER IS AUTOMATICALLY SET TO HIGH RANGE DURING TEST,
CHECK BOX 8c MULTIPLY AXIAL STRESS $\times 4$

☒ X

AXIAL STRESS
IN LBS/SQ FT



AXIAL STRESS IN LBS/SQ FT

5000

4000

3000

2000

1000

0

AXIAL DEFLECTION IN INCHES

0

.5

1.0

1.5

2.0

5651-003
JOB NO.

2
BORING NO.

3.0'
DEPTH

ML-FILL
SOIL TYPE

BY MCB/5/2
TESTED

CHICAGO
OFFICE

4,500
CONFINING
PRESSURE

☒ X FIELD
MOISTURE

☐ SATURATED
TEST

TX-QT
TYPE OF TEST

NOTES

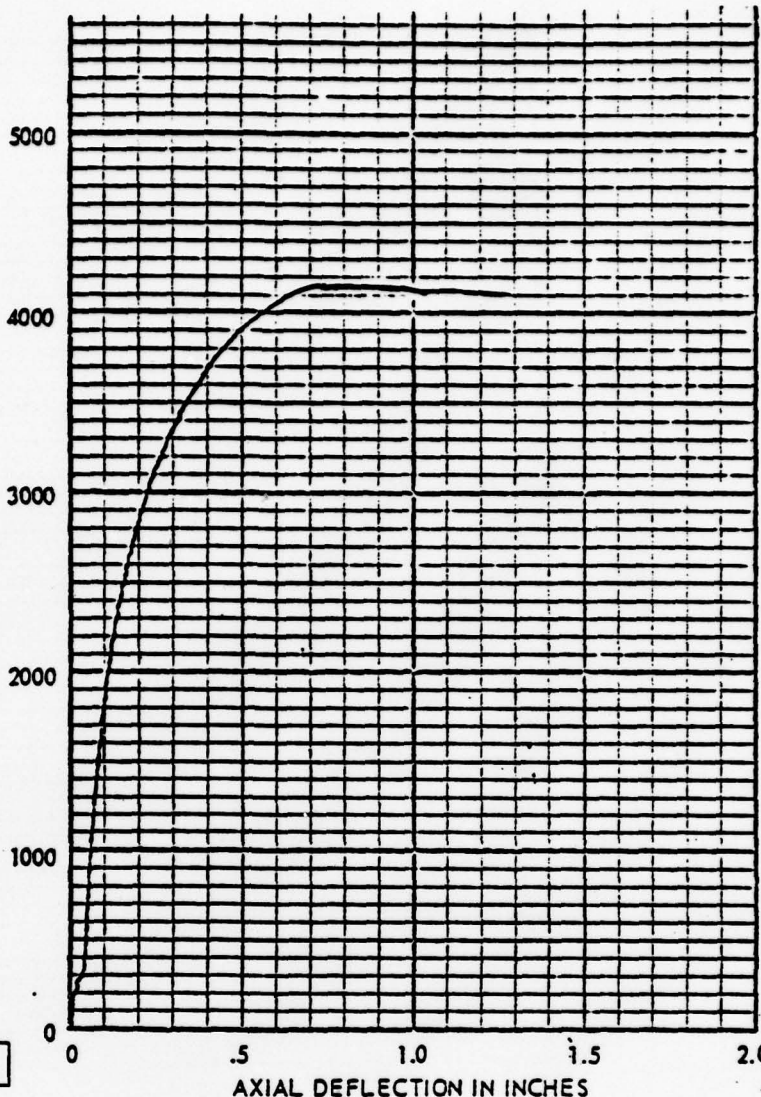
| | | | | | |
|---------------------|---------------------------|------------------|------------------|--------------------------------|--------------------|
| MOISTURE CONTENT | Dish No. | I | SAMPLE VOLUME | Net diameter | D_o _____ in. |
| | Wet weight soil & dish | 139.0 | | Area $(0.785 D_o^2)$ | A _____ sq.in. |
| | Dry weight soil & dish | 118.4 | | Height | H_o 5.75 in. |
| | Net loss of moisture | 20.6 | | Volume $(A_o H_o) = 1728$ | V_o _____ cu.ft. |
| | Weight of dish only | 25.0 | | Volume $(A_o H_o) = 16.4$ | V_o _____ cc |
| | Net weight of dry soil | 93.4 | | Specific gravity of solids | G_s _____ |
| DRY DENSITY | Moisture, % of dry weight | 22.0 | VOID RATIO | Volume of solids $W_s - G_s$ | V_s _____ cc |
| | Wt. solids + moisture | W_o 256.0 gms. | | $(V_o - V_s) = V_s$ | e_i _____ |
| | $W_o = 454$ | W_o _____ lbs. | | Initial burette reading | _____ cc |
| | Weight solids | W_s _____ gms. | | Burette reading under pressure | _____ cc |
| | Wet density $W_o' - V_o'$ | 123.2 pcf | | $(V_p - V_s) = V_s$ | e_p _____ |
| | Dry density | 101 pcf | | VI-50 | |

IF HIGH RANGE MODE OF RECORDING DATA IS SET AT BEGINNING OF TEST,
OR IF RECORDER IS AUTOMATICALLY SET TO HIGH RANGE DURING TEST,
CHECK BOX 8c MULTIPLY AXIAL STRESS $\times 4$



AXIAL STRESS
IN LBS/SQ FT

AXIAL STRESS IN LBS/SQ FT



AXIAL DEFLECTION IN INCHES

JOB NO.

3^{2A}

BORING NO.

3

DEPTH

APCL 51.4/
SO 58.35V

SOIL TYPE

BY RTH 6/1/6
TESTED

CH

OFFICE

4500

CONFINING
PRESSURE

☒ FIELD
MOISTURE

☐ SATURATED
TEST

TRIAx:U-U
TYPE OF TEST

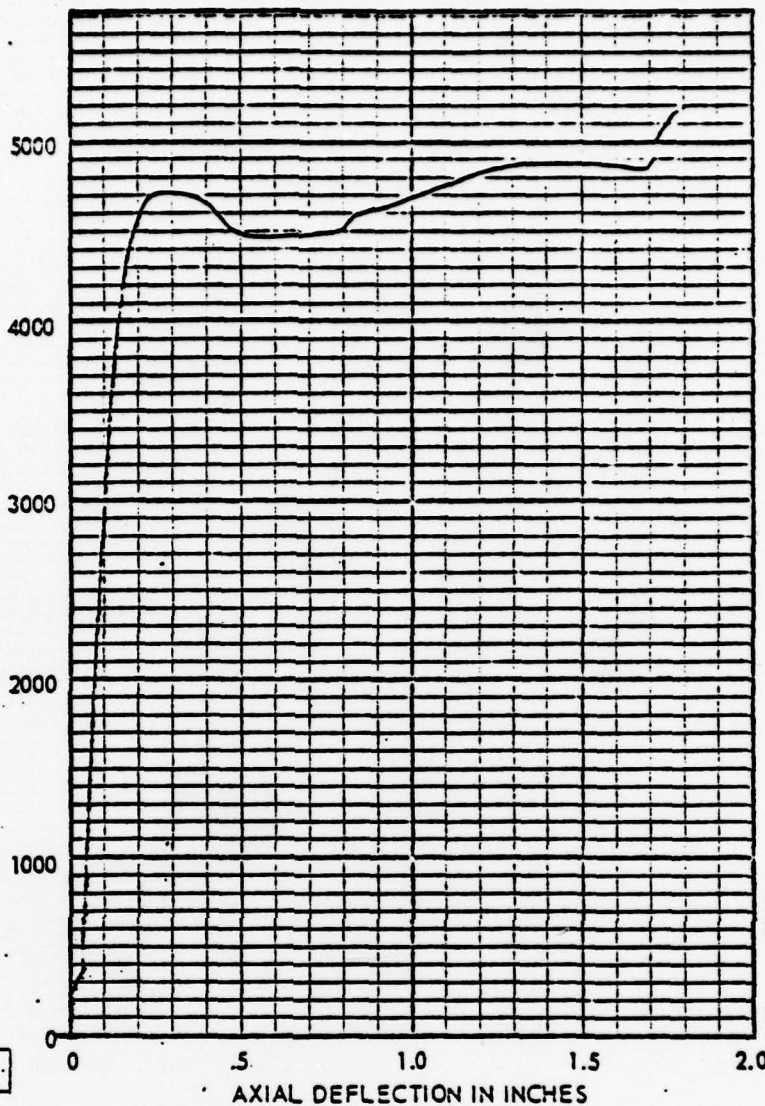
NOTES

| | | | | | |
|---------------------|---|---------------------------|------------------|---|-----------------------------|
| MOISTURE CONTENT | Dish No. | Y | SAMPLE VOLUME | Net diameter | D ₀ _____ in. |
| | Wet weight soil & dish | 158.5 | | Area (0.785 D ₀ ²) | A _____ sq.in. |
| | Dry weight soil & dish | 136.5 | | Height | H ₀ 4.87 in. |
| | Net loss of moisture | 22.0 | | Volume (A ₀ H ₀) ÷ 1728 | V ₀ _____ cu.ft. |
| | Weight of dish only | 24.8 | | Volume (A ₀ H ₀) ÷ 16.4 | V ₀ _____ cc |
| | Net weight of dry soil | 111.7 | | Specific gravity of solids | G _s _____ |
| DRY DENSITY | Moisture, % of dry weight | 19.7 | VOID RATIO | Volume of solids W _s ÷ G _s | V _s _____ cc |
| | Wt. solids - moisture | W ₀ 757 gms. | | (V ₀ - V _s) - V _s | e _i _____ |
| | W ₀ ÷ 454 | W ₀ _____ lbs. | | Initial burette reading | _____ cc |
| | Weight solids | W _s _____ gms. | | Burette reading under pressure | _____ cc |
| | Wet density W ₀ ' - V ₀ | 129.5 pcf | | (V _p - V _s) - V _s | e _p _____ |
| | Dry density | 108 pcf | VI-51 | | |

IF HIGH RANGE MODE OF RECORDING DATA IS SET AT BEGINNING OF TEST,
OR IF RECORDER IS AUTOMATICALLY SET TO HIGH RANGE DURING TEST,
CHECK BOX 8c MULTIPLY AXIAL STRESS x 4



AXIAL STRESS IN LBS/SQ FT



AXIAL STRESS
IN LBS SQ FT

AXIAL DEFLECTION IN INCHES

5651-00
JOB NO.

3
BORING NO.

6.0'
DEPTH

ML-FILL
SOIL TYPE

BY HRS / S /
TESTED

CHICAGO
OFFICE

4500
CONFINING
PRESSURE

☒ FIELD
MOISTURE

☐ SATURATED
TEST

TX-0 TVL
TYPE OF TEST

NOTES

| | | | | | |
|---------------------|---|---------------------------|------------------|---|-----------------------------|
| MOISTURE CONTENT | Dish No. | 14 | SAMPLE VOLUME | Net diameter | D _o _____ in. |
| | Wet weight soil & dish | 165.1 | | Area (0.785 D _o ²) | A _____ sq.in. |
| | Dry weight soil & dish | 141.0 | | Height | H _o 5.80 in. |
| | Net loss of moisture | 24.1 | | Volume (A _o H _o) ÷ 1728 | V _o _____ cu.ft. |
| | Weight of dish only | 24.5 | | Volume (A _o H _o) ÷ 16.4 | V _o _____ cc |
| | Net weight of dry soil | 116.5 | | Specific gravity of solids | G _s _____ |
| DRY DENSITY | Moisture, % of dry weight | 20.7 | VOID RATIO | Volume of solids W _s ÷ G _s | V _s _____ cc |
| | Wt. solids - moisture | W _o 278.3 gms. | | (V _o - V _s) ÷ V _s | e _i _____ |
| | W _o ÷ 454 | W _o _____ lbs. | | Initial burette reading | _____ cc |
| | Weight solids | W _s _____ gms. | | Burette reading under pressure | _____ cc |
| | Wet density W _o ÷ V _o | 125.4 pcf | | (V _o - V _s) - V _s | e _p _____ |
| | Dry density | 104 pcf | | VI-52 | |

357.42
APR 10 1964
UNIVERSITY OF MICHIGAN LIBRARY

OWNER Baker Engr. Co LOCATION Orange County JOB # 6651-003-07
 SOIL TYPE Brown, Red & Yellow clayey sandy BORING # 3
Silt (ML-Fill) DEPTH 13.5'
 SAMPLE # 6A

SAMPLED JBR 5/12/67

SET-UP 1 / 1

TESTED SW 5/21/67

(SE OFFICE)

SATURATED TEST ☐

FIELD MOISTURE TEST 8

TEST LATERAL PRESSURE 1500 PSF

TYPE OF TEST IS/m

104

SR. 20.125"/in.2

Weight soil & dish no.

285.1

Net diameter

D₀ 2.42 in.

Dry weight soil & dish

244.9

Area ($0.785 D_0^2$)

A₀ 4.60 sq.in.

Net loss of moisture

40.2

Height

H₀ 5.70 in.

Weight of dish only

16.4

Volume ($A_0 H_0$) + 1728

V₀ cu.ft.

Net weight of dry soil

16.4

Volume ($A_0 H_0$) × 16.4

V₀ cc

Moisture, % of dry weight

16.4

Specific gravity of solids

G_s

Volume of solids $W_s + G_s$

V_s cc

$(V_0 - V_s) + V_s$

e_i

Initial burette reading

cc

Burette reading under pressure

cc

$(V_p - V_s) + V_s$

e_p

Wt. solids + moisture

W₀ 885 gms.

$W_0 + 454$

W₀ lbs.

Weight solids

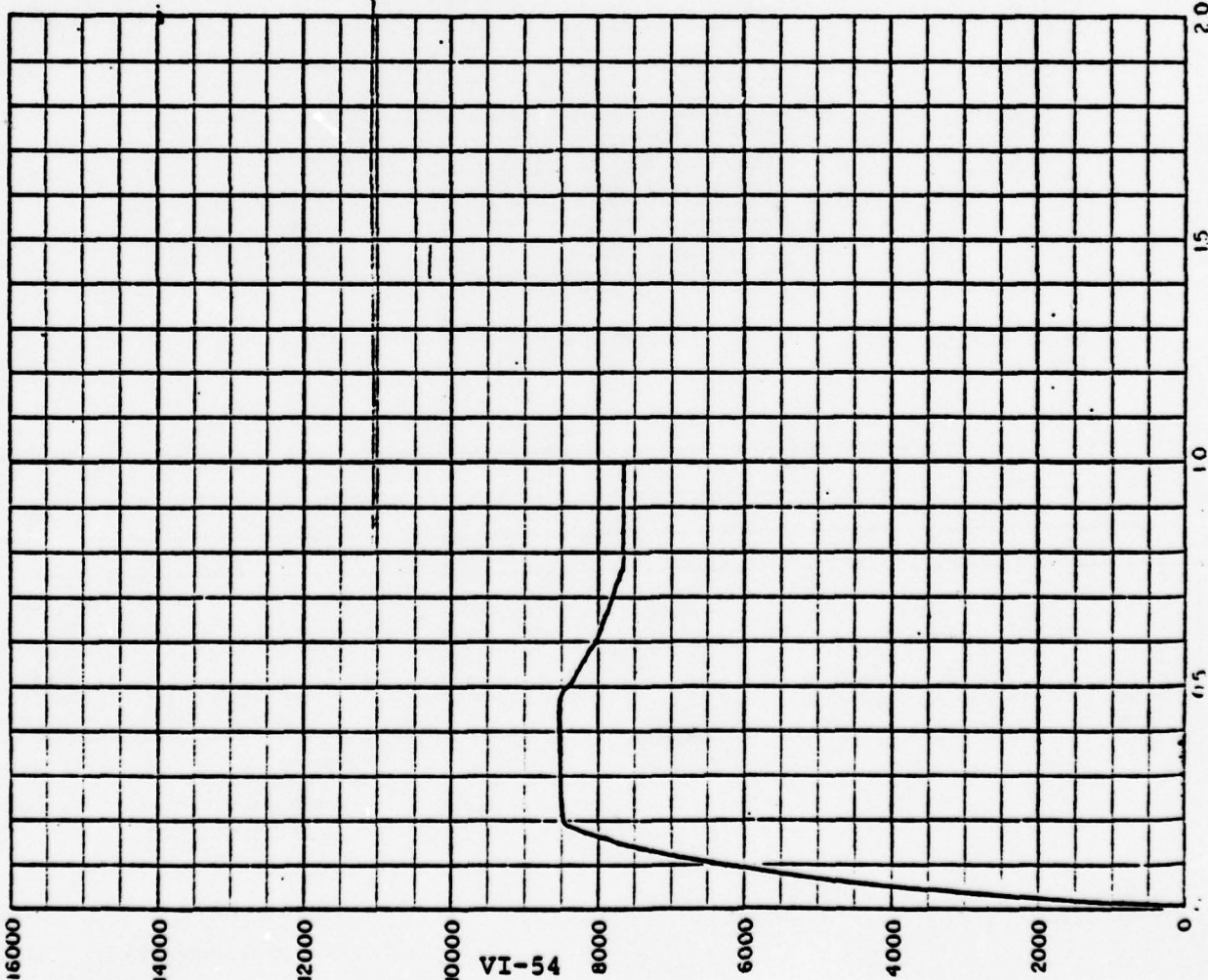
W_s gms.

Wet density $W_0' + V_0'$

129 pcf

Dry density

111 pcf



AXIAL STRESS IN LBS./SQ. FT. (X.30 FOR HI-RANGE)

OWNER Bayer Edge Co. LOCATION Orange County BORING # 3
 SOIL TYPE Red Brown & Yellow Sandy Clayey Silt DEPTH 16.0
With Gravel & Decomposed Siliceous Fragments (UL-Fill) SAMPLE # 7A
 SAMPLED RR 5/12/67 SET-UP 1 / 1 TESTED 5/21/67 (SE OFFICE)

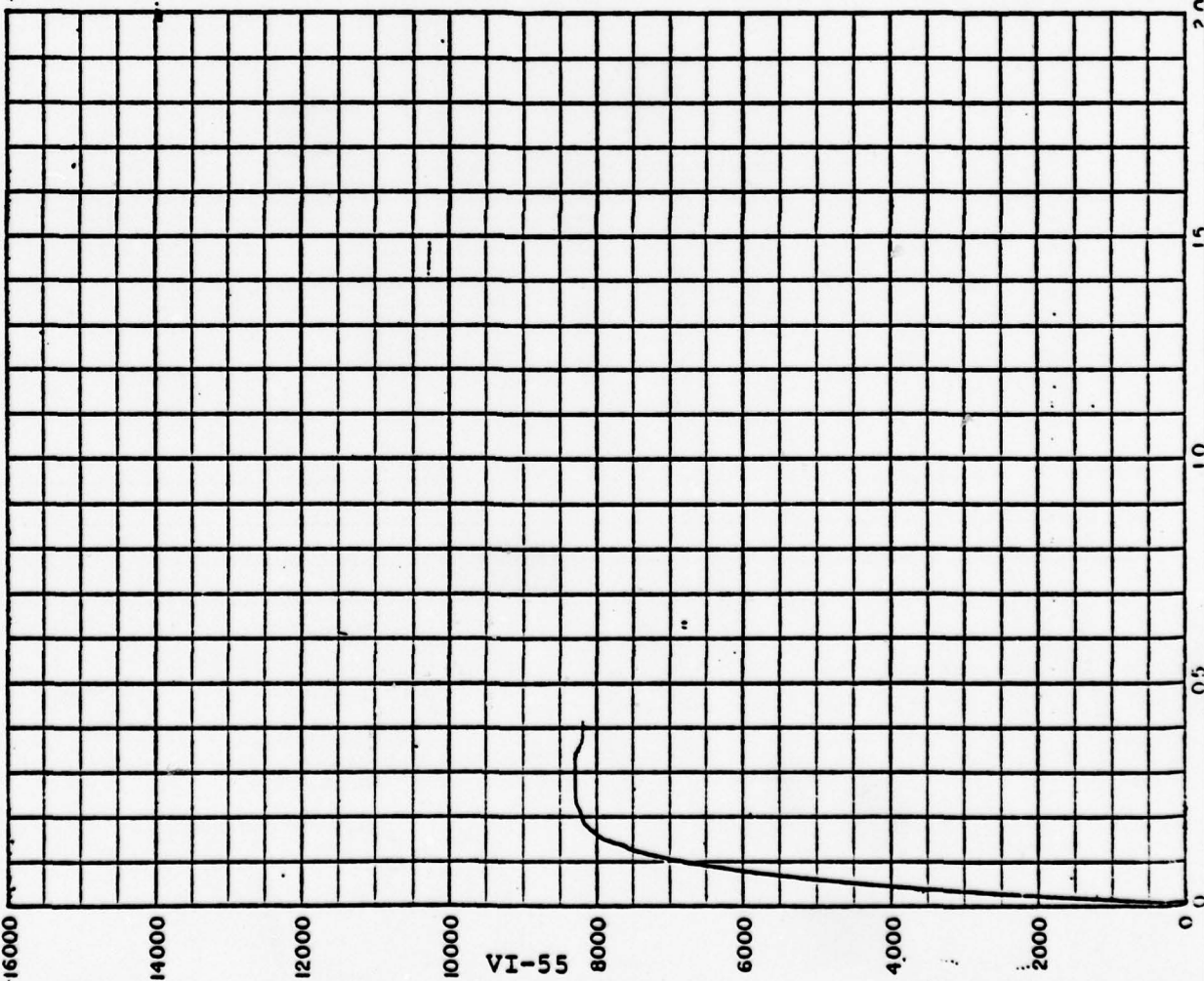
SATURATED TEST ☐ FIELD MOISTURE TEST ☒ TEST LATERAL PRESSURE 3000 PSF
 TYPE OF TEST TR/LIM 372 BR. = 0.125" / MIN.

Weight soil & dish no. 279.5
 Dry weight soil & dish 240.8
 Net loss of moisture 38.7
 Weight of dish only
 Net weight of dry soil
 Moisture, % of dry weight 16.1



Net diameter D₀ 2.42 in.
 Area A₀ 4.60 sq. in.
 Height H₀ 6.0 in.
 Volume (A₀H₀) + 1728
V₀ cu. ft.
 Volume (A₀H₀) = 16.4
V₀ cc
 Specific gravity of solids G_s
 Volume of solids W_s + G_s
V_s cc
(V₀ - V_s) + V_s
e_i
 Initial burette reading cc
 Burette reading under pressure cc
(V_p - V_s) + V_s
e_p

Wt. solids + moisture W₀ 513 gms.
W₀ + 454
W₀ lbs.
 Weight solids W_s gms.
 Wet density W₀' + V₀'
127 pcf
 Dry density 109 pcf



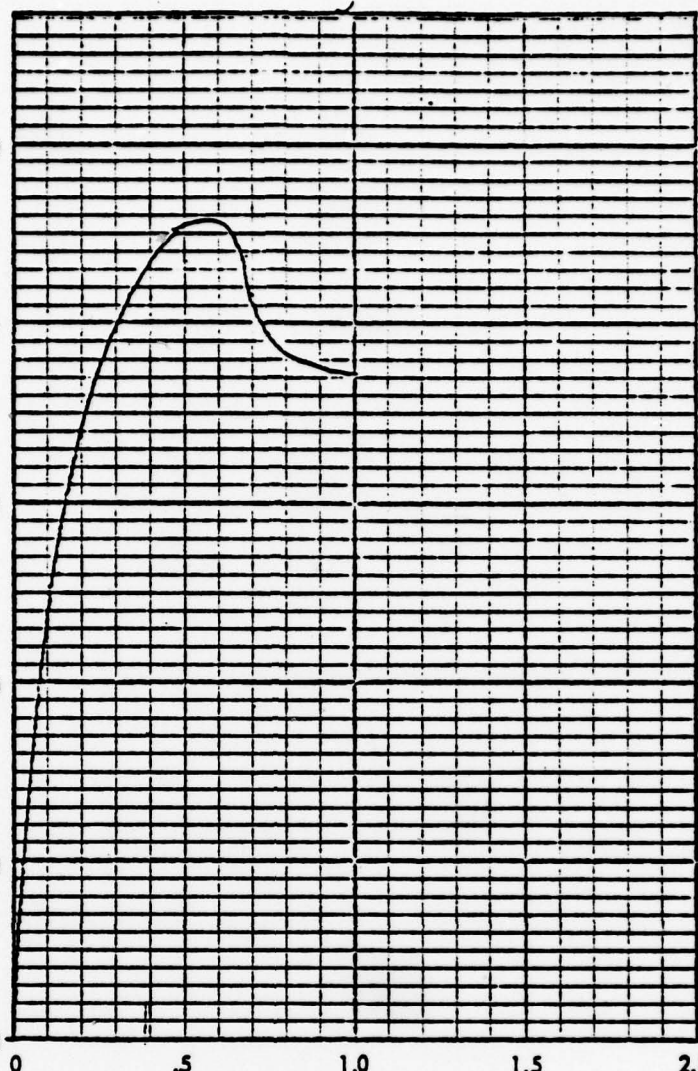
IF HIGH RANGE MODE OF RECORDING DATA IS SET AT BEGINNING OF TEST,
OR IF RECORDER IS AUTOMATICALLY SET TO HIGH RANGE DURING TEST,
CHECK BOX 8c MULTIPLY AXIAL STRESS $\times 4$



AXIAL STRESS
IN LBS/SQ FT

AXIAL STRESS IN LBS/SQ FT

5000
4000
3000
2000
1000
0



AXIAL DEFLECTION IN INCHES

2621-003
JOB NO.

381
BORING NO.

18 1/2
DEPTH

BRACED
W/3.5 IN. DIAM.
SOIL TYPE

BY RHT 6/1/67
TESTED

CH
OFFICE

3000
CONFINING
PRESSURE

☒ FIELD
MOISTURE

☐ SATURATED
TEST

TRIAX:U-
TYPE OF TEST

NOTES

| | | | | | |
|---------------------|---|---------------------------|------------------|---|-----------------------------|
| MOISTURE CONTENT | Dish No. | R | SAMPLE VOLUME | Net diameter | D _o _____ in. |
| | Wet weight soil & dish | 197.1 | | Area (0.785 D _o ²) | A _____ sq.in. |
| | Dry weight soil & dish | 170.2 | | Height | H _o 4.86 in. |
| | Net loss of moisture | 26.9 | | Volume (A _o H _o) = 1728 | V _o _____ cu.in. |
| | Weight of dish only | 24.4 | | | |
| | Net weight of dry soil | 145.8 | | | |
| DRY DENSITY | Moisture, % of dry weight | 18.5 | VOID RATIO | Volume (A _o H _o) = 16.4 | V _o _____ cc |
| | Wt. solids - moisture | W _o 757 gms. | | Specific gravity of solids | G _s _____ |
| | W _o + 454 | W _o _____ lbs. | | Volume of solids W _s + G _s | V _s _____ cc |
| | Weight solids | W _s _____ gms. | | (V _o - V _s) = V _s | e _i _____ |
| | Wet density W _o ' - V _o | 130 pcf | | Initial burette reading | _____ cc |
| | Dry density | 110 ccf | | Burette reading under pressure | _____ cc |
| | | | VI-56 | (V _p - V _s) - V _s | e _p _____ |

ATTACHMENT C
CONSOLIDATION TESTS
FOR VERTICAL PERMEABILITIES

JOB Recon. & ImprovementJOB NO. 51.51-003-07DATE SAMPLED 5-15-67BORING NO. 1TEST STARTED 8:00 AM BY W. J. H. TEST FINISHED 11:00 AM BY W. J. H.DEPTH 5.0SOIL TYPE Red-brown clay, sandy silty with gravel (46)CONSOLIDOMETER NO. 9INITIAL SAMPLE HEIGHT 1.00 in.

| MOISTURE & DENSITY DATA | BEFORE TEST | AFTER TEST |
|--|-------------|------------|
| WT. OF RING(S) + SOIL | 197.10 | 197.45 |
| WT. OF RING(S) ONLY | 45.10 | 45.10 |
| WT. OF SOIL (NET) | 152.00 | 152.35 |
| WET DENSITY IN LBS/CU. FT.* | 127 | 127 |
| WT. OF WET SOIL + DISH NO. <u>405A</u> | 195.55 | 192.45 |
| INT. OF DRY SOIL + DISH | 176.34 | 171.60 |
| WT. OF LOST MOISTURE | 21.91 | 25.25 |
| WT. OF DISH ONLY | 56.13 | 45.10 |
| WT. OF DRY SOIL | 120.21 | 126.50 |
| MOISTURE AS % OF DRY WT. | 18.2 | 20.4 |
| DRY DENSITY IN LBS/CU. FT. | 127 | 106 |

TEST INSTRUCTIONS

LOAD CYCLE

1. 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 <

| DATE | TIME | E. LAPPED TIME IN MINS. | LOAD (PSF) | DIAL READING (1.0001 IN.) | CONSO. UNDER THIS LOAD | TOTAL CONSO. LOCATION |
|------|------|-------------------------|------------|---------------------------|------------------------|-----------------------|
| | | | 2450 | | | |
| | 1045 | 2 | | 4356 | | |
| | | 10 | | 4446 | | |
| | | 15 | | 4435 | | |
| | | 20 | | 4426 | | |
| | 941 | 1 | | 4419 | | |
| | | 2 | | 4411 | | |
| | 943 | 4 | | 4404 | | |
| | 949 | 9 | | 4317 | | |
| | 955 | 15 | | 4394 | | |
| | 1010 | 20 | | 4390 | | |
| | 1040 | 20 | | 4387 | | |
| | 1140 | 120 | | 4383 | | |
| | 1540 | 240 | | 4379 | | 4765 |
| | 1740 | 480 | | 4374 | | 4371 |
| 5-22 | 1840 | 1840 | | 4371 | | 0294 |
| | | | 12200 | | | |
| | 1040 | 0 | | 41371 | | |
| | | 6 | | 4248 | | |
| | | 15 | | 4233 | | |
| | | 20 | | 4219 | | |
| | 941 | 1 | | 4204 | | |
| | 949 | 2 | | 4189 | | |
| | 940 | 4 | | 4174 | | |
| | 940 | 9 | | 4160 | | |
| | 955 | 15 | | 4160 | | |
| | 1010 | 30 | | 4155 | | |
| | 1040 | 60 | | 4151 | | |
| | 1140 | 120 | | 4142 | | |
| | 1340 | 240 | | 4144 | | 4765 |
| | 1740 | 480 | | 4141 | | 4135 |
| 5-23 | 940 | 1440 | | 4135 | | 0634 |
| | | | 25600 | | | |
| | 945 | 0 | | 4135 | | |
| | | 6 | | 3997 | | |
| | | 15 | | 3975 | | |
| | | 20 | | 3954 | | |
| | 946 | 1 | | 3929 | | |
| | 947 | 2 | | 3901 | | |
| | 949 | 4 | | 3890 | | |
| | 954 | 9 | | 3863 | | |
| | 1000 | 15 | | 3856 | | |
| | 1005 | 30 | | 3850 | | |
| | 1045 | 60 | | 3845 | | |
| | 1245 | 180 | | 3838 | | |
| | 1445 | 300 | | 3835 | | 4165 |
| | 1745 | 480 | | 3830 | | 3727 |
| 5-24 | 1845 | 1840 | | 3827 | | 932 |
| | | | 51200 | | | |
| | 945 | 0 | | 3827 | | |
| | | 6 | | 3682 | | |
| | | 15 | | 3662 | | |
| | | 30 | | 3632 | | |
| | 946 | 1 | | 3616 | | |
| | 947 | 2 | | 3571 | | |
| | 949 | 4 | | 3540 | | |
| | 954 | 9 | | 3525 | | |

| DATE | TIME | E. LAPPED TIME IN MINS. | LOAD (PSF) | DIAL READING (1.0001 IN.) | CONSO. UNDER THIS LOAD | TOTAL CONSO. LOCATION |
|------|------|-------------------------|------------|---------------------------|------------------------|-----------------------|
| | 1040 | 15 | | 3518 | | |
| | 1045 | 20 | | 3511 | | |
| | 1045 | 20 | | 3506 | | |
| | 1145 | 120 | | 3501 | | |
| | 1345 | 240 | | 3497 | | 4765 |
| | 1745 | 480 | | 3493 | | 3482 |
| 5-25 | 945 | 1440 | | 3487 | | 1578 |
| | | | 102,400 | | | |
| | 945 | 0 | | 3487 | | |
| | | 6 | | 3350 | | |
| | | 15 | | 3318 | | |
| | | 30 | | 3257 | | |
| | 946 | 1 | | 3245 | | |
| | 947 | 2 | | 3202 | | |
| | 949 | 4 | | 3160 | | |
| | 954 | 9 | | 3145 | | |
| | 1000 | 15 | | 3130 | | |
| | 1015 | 30 | | 3132 | | |
| | 1045 | 60 | | 3125 | | |
| | 1145 | 120 | | 3121 | | |
| | 1345 | 240 | | 3117 | | 4765 |
| | 1745 | 480 | | 3113 | | 3105 |
| 5-26 | 945 | 1440 | | 3105 | | 1660 |
| | | | 100 | | | |
| | 946 | 1 | | 3431 | | |
| | 1400 | | | 3986 | | |
| | 1800 | | | 4001 | | |

WORK SHEET - SPECIFIC GRAVITY TESTS

Project: Saurashtra Engr. Co. Job No. 551-005 Hole No. 1 Date 5/21/67

SPECIFIC GRAVITY OF SOLIDS (G_s)

| | | | | | | |
|---|-----------|---------------|--------------|--|--|--|
| Sample No. | | <u>2A</u> | <u>213.0</u> | | | |
| Flask No. | | <u>A</u> | | | | |
| Temperature of Water and Soil, T , $^{\circ}\text{C}$ | | <u>22.5</u> | | | | |
| Pan No. | | | | | | |
| Pan + Dry Soil | | <u>446.03</u> | | | | |
| Pan | | <u>327.76</u> | | | | |
| Dry Soil | W_s | <u>118.27</u> | | | | |
| Flask + Water at T , $^{\circ}\text{C}$ | W_{bw} | <u>651.31</u> | | | | |
| $W_s + W_{bw}$ | | <u>769.58</u> | | | | |
| Flask + Water + Immersed Soil | W_{bws} | <u>733.88</u> | | | | |
| Displaced Water, $W_s + W_{bw} - W_{bws}$ | | <u>35.70</u> | | | | |
| Correction Factor | K | <u>0.9996</u> | | | | |
| $(W_s K) \div (W_s + W_{bw} - W_{bws})$ | G_s | <u>2.71</u> | | | | |

APPARENT (G_a) AND BULK (G_m) SPECIFIC GRAVITY

| Sample No. | | Temp. | Corr. Factor |
|---|-------|--------------------|---------------|
| | | $^{\circ}\text{C}$ | K |
| Temperature of Water and Soil, T , $^{\circ}\text{C}$ | | <u>14</u> | <u>1.0010</u> |
| Pan + Saturated Surface - Dry Soil | | <u>15</u> | <u>1.0009</u> |
| Tare Weight | | <u>16</u> | <u>1.0007</u> |
| Saturated Surface - Dry Soil | B | <u>17</u> | <u>1.0006</u> |
| (Wire Basket + Soil) in Water | | <u>18</u> | <u>1.0004</u> |
| Wire Basket in Water | | <u>19</u> | <u>1.0002</u> |
| Saturated Soil in Water | C | <u>20</u> | <u>1.0000</u> |
| Tare Weight + Dry Soil | | <u>21</u> | <u>0.9998</u> |
| Tare Weight | | <u>22</u> | <u>0.9996</u> |
| Dry Soil | A | <u>23</u> | <u>0.9993</u> |
| Correction Factor | K | <u>24</u> | <u>0.9991</u> |
| $(AK) \div (A-C)$ (Apparent) | G_a | <u>25</u> | <u>0.9988</u> |
| $(AK) \div (B-C)$ (Bulk) | G_m | <u>26</u> | <u>0.9986</u> |
| Remarks: | | <u>27</u> | <u>0.9983</u> |
| | | <u>28</u> | <u>0.9980</u> |
| | | <u>29</u> | <u>0.9977</u> |
| | | <u>30</u> | <u>0.9974</u> |
| | | <u>31</u> | <u>0.9971</u> |

Tested by: P.C. Computed by: B.C. Checked by: [Signature]

JOB 2000-10-10-10

JOB NO. 2000-10-10-10

DATE SAMPLED 5-18-64

BORING NO. 25

TEST STARTED 5:00 BY W.D. TEST FINISHED 5:00 BY W.D.

DEPTH 1.5

SOIL TYPE CLAY

CONSOLIDOMETER NO. 14

INITIAL SAMPLE HEIGHT 1.5

| MOISTURE & DENSITY DATA | BEFORE TEST | AFTER TEST |
|---------------------------------------|-------------|------------|
| WT. OF RING(S) - SOIL | 192.64 | 192.34 |
| WT. OF RING(S) ONLY | 44.90 | 44.90 |
| WT. OF SOIL (NET) | 147.74 | 147.44 |
| WET DENSITY IN LBS/CU. FT.* | 123.0 | 123.0 |
| WT. OF WET SOIL - DISH NO. <u>253</u> | 185.73 | 193.34 |
| INT. OF DRY SOIL - DISH | 141.15 | 146.00 |
| WT. OF LOST MOISTURE | 24.58 | 26.84 |
| WT. OF DISH ONLY | 55.44 | 44.90 |
| WT. OF DRY SOIL | 125.71 | 121.60 |
| MOISTURE AS % OF DRY WT. | 23.3 | 22.1 |
| DRY DENSITY IN LBS/CU. FT. | 100 | 101 |

TEST INSTRUCTIONS

LOAD CYCLE _____

SPECIAL INSTRUCTION AND NOTES

1. Initial load
2. Initial load
3. Initial load

| DATE | TIME | E-LAPSED TIME IN MINS. | LOAD (PSF) | DIAL READING (.0001 IN.) | CONSOL. UNDER THIS LOAD | TOTAL CONSOL. IDATION |
|------|-------|------------------------|------------|--------------------------|-------------------------|-----------------------|
| 5-18 | | | 0 | | | |
| | 12:00 | | 100 | 40.10 | | |
| | 3:05 | | 25 | 40.03 | | 0.026 |
| | 13:00 | | 25 | 40.03 | | |
| | 13:00 | | 25 | 40.03 | | |
| | 13:00 | | 25 | 40.03 | | |
| | 15:40 | | | 40.02 | | 40.10 |
| | 17:40 | | | 40.01 | | 40.01 |
| | 18:00 | | 400 | 40.03 | | 40.03 |
| 5-19 | 8:35 | | | 40.03 | | 40.03 |
| | 10:20 | | 800 | 40.01 | | 40.01 |
| | 10:30 | 0 | | 40.01 | | |
| | 1 | 6 | | 40.00 | | |
| | 1 | 15 | | 40.00 | | |
| | 1 | 20 | | 40.00 | | |
| | 10:20 | 1 | | 40.00 | | |
| | 10:30 | 2 | | 40.00 | | |
| | 10:30 | 9 | | 40.00 | | |
| | 10:40 | 15 | | 40.00 | | |
| | 10:50 | 30 | | 40.00 | | |
| | 11:20 | 40 | | 40.00 | | |
| | 12:20 | 100 | | 40.00 | | |
| | 14:20 | 200 | | 40.00 | | |
| | 14:20 | 200 | | 40.00 | | |

| DATE | TIME | E-LAPSED TIME IN MINS. | LOAD (PSF) | DIAL READING (.0001 IN.) | CONSOL. UNDER THIS LOAD | TOTAL CONSOL. IDATION |
|------|-------|------------------------|------------|--------------------------|-------------------------|-----------------------|
| 5-20 | 10:25 | 40 | | 40.07 | | 40.07 |
| | 10:30 | 1400 | | 40.07 | | 40.07 |
| | | | 1600 | | | |
| | 10:25 | 0 | | 40.00 | | |
| | 1 | 6 | | 40.00 | | |
| | 1 | 15 | | 40.00 | | |
| | 1 | 20 | | 40.00 | | |
| | 10:20 | 1 | | 40.00 | | |
| | 10:30 | 2 | | 40.00 | | |
| | 10:30 | 11 | | 40.00 | | |
| | 10:30 | 11 | | 40.00 | | |
| | 10:40 | 15 | | 40.00 | | |
| | 10:50 | 20 | | 40.00 | | |
| | 11:20 | 40 | | 40.00 | | |
| | 12:20 | 100 | | 40.00 | | |
| | 14:20 | 200 | | 40.00 | | |
| | 14:20 | 200 | | 40.00 | | |
| 5-21 | 07:20 | 1000 | | 40.00 | | 40.00 |
| | | | 3200 | | | |
| | 10:20 | 0 | | 40.00 | | |
| | 1 | 6 | | 40.00 | | |
| | 1 | 15 | | 40.00 | | |
| | 1 | 20 | | 40.00 | | |
| | 10:20 | 1 | | 40.00 | | |
| | 10:30 | 2 | | 40.00 | | |
| | 10:30 | 4 | | 40.00 | | |
| | 10:40 | 15 | | 40.00 | | |
| | 10:50 | 30 | | 40.00 | | |
| | 11:20 | 40 | | 40.00 | | |
| | 12:20 | 100 | | 40.00 | | |
| | 14:20 | 200 | | 40.00 | | |

*MULTIPLY WEIGHT OF SOIL IN GRAMS BY 0.832 WHEN ONE STANDARD O & M SAMPLE IS USED.

CONTINUED ON REVERSE SIDE

| DATE | TIME | LAPSED TIME IN MINS. | LOAD (PSF) | DIAL READING (1.0001 IN.) | UNDER THIS LOAD | TOTAL CONSOL. IDATION |
|------|------|----------------------|------------|---------------------------|-----------------|-----------------------|
| | | | 3200 | 4701 | | 4919 |
| | 1205 | 120 | | 4701 | | 4919 |
| | 1405 | 240 | | 4699 | | 4925 |
| | 1605 | 440 | | 4696 | | 4925 |
| 5-22 | 1305 | 1412 | | 4694 | | |
| | | | 1400 | | | |
| | 1005 | 5 | | 4694 | | |
| | 7 | 6 | | 4609 | | |
| | 7 | 15 | | 4604 | | |
| | 1 | 30 | | 4600 | | |
| | 1006 | 1 | | 4601 | | |
| | 1017 | 2 | | 4599 | | |
| | 1020 | 4 | | 4597 | | |
| | 1014 | 9 | | 4595 | | |
| | 1020 | 15 | | 4593 | | |
| | 1020 | 20 | | 4592 | | |
| | 1105 | 40 | | 4590 | | |
| | 1205 | 100 | | 4587 | | |
| | 1405 | 240 | | 4585 | 4919 | |
| | 1805 | 440 | | 4583 | 4501 | |
| 5-22 | 1005 | 1410 | | 4581 | 0330 | |
| | | | 1200 | | | |
| | 1005 | 0 | | 4581 | | |
| | 7 | 6 | | 4471 | | |
| | | 15 | | 4464 | | |
| | | 30 | | 4458 | | |
| | 1006 | 1 | | 4453 | | |
| | 1007 | 2 | | 4450 | | |
| | 1009 | 4 | | 4447 | | |
| | 1014 | 9 | | 4443 | | |
| | 1020 | 15 | | 4441 | | |
| | 1035 | 30 | | 4439 | | |
| | 1105 | 40 | | 4437 | | |
| | 1305 | 140 | | 4433 | | |
| | 1505 | 240 | | 4431 | 4919 | |
| | 1805 | 440 | | 4429 | 4432 | |
| 5-24 | 1005 | 1410 | | 4427 | 0492 | |
| | | | 2500 | | | |
| | 1115 | 0 | | 4427 | | |
| | 7 | 6 | | 4251 | | |
| | | 15 | | 41742 | | |
| | | 30 | | 4235 | | |
| | 1006 | 1 | | 4230 | | |
| | 1007 | 2 | | 4225 | | |
| | 1009 | 4 | | 4221 | | |
| | 1014 | 9 | | 4217 | | |
| | 1020 | 15 | | 4214 | | |
| | 1025 | 20 | | 4211 | | |
| | 1105 | 40 | | 4207 | | |
| | 1205 | 100 | | 4205 | | |
| | 1405 | 240 | | 4201 | 4919 | |
| | 1805 | 440 | | 4198 | 4195 | |
| 5-25 | 1005 | 1410 | | 4195 | 0724 | |

| DATE | TIME | LAPSED TIME IN MINS. | LOAD (PSF) | DIAL READING (1.0001 IN.) | UNDER THIS LOAD | TOTAL CONSOL. IDATION |
|------|------|----------------------|------------|---------------------------|-----------------|-----------------------|
| | | | 5720 | | | |
| | 1000 | 0 | | 4195 | | |
| | 7 | 6 | | 3955 | | |
| | | 5 | | 3939 | | |
| | | 30 | | 3928 | | |
| | 1001 | 1 | | 3918 | | |
| | 1002 | 2 | | 3911 | | |
| | 1004 | 4 | | 3905 | | |
| | 1009 | 9 | | 3898 | | |
| | 1015 | 15 | | 3895 | | |
| | 1020 | 20 | | 3890 | | |
| | 1100 | 60 | | 3887 | | |
| | 1200 | 120 | | 3883 | | |
| | 1400 | 240 | | 3870 | 4919 | |
| | 1800 | 480 | | 3878 | 3872 | |
| 5-26 | 1000 | 1410 | | 3872 | 1047 | |
| | | | 102000 | | | |
| | 1000 | 0 | | 3872 | | |
| | 7 | 6 | | 3566 | | |
| | | 15 | | 3512 | | |
| | | 30 | | 3460 | | |
| | 1001 | 1 | | 3472 | | |
| | 1002 | 2 | | 3462 | | |
| | 1004 | 4 | | 3450 | | |
| | 1009 | 9 | | 3413 | | |
| | 1015 | 15 | | 3357 | | |
| | 1020 | 20 | | 3351 | | |
| | 1100 | 60 | | 3305 | | |
| | 1200 | 120 | | 3200 | | |
| | 1400 | 240 | | 3215 | | |
| | 1800 | 480 | | 3211 | | |
| 5-27 | 1000 | 1410 | | | | |
| | | | 100 | | | |
| | 1801 | 1 | | 3900 | | |

WORK SHEET - SPECIFIC GRAVITY TESTS

| | | | | |
|--|---|-------------------------|-------------------|--------------------|
| Project: <u>Dawson Edison Co</u> | | Job No. <u>5451-003</u> | Hole No. <u>3</u> | Date <u>5/2/67</u> |
| SPECIFIC GRAVITY OF SOLIDS (G_s) | | | | |
| Sample No. | <u>1</u> | <u>T.S.</u> | | |
| Flask No. | <u>C</u> | | | |
| Temperature of Water and Soil, T , $^{\circ}C$ | <u>22.5</u> | | | |
| Pan No. | | | | |
| Wt. in grams | Pan + Dry Soil | <u>393.26</u> | | |
| | Pan | <u>283.07</u> | | |
| | Dry Soil | W_s <u>110.19</u> | | |
| | Flask + Water at T , $^{\circ}C$ | W_{bw} <u>651.24</u> | | |
| | $W_s + W_{bw}$ | <u>761.48</u> | | |
| | Flask + Water + Immersed Soil | W_{bws} <u>727.26</u> | | |
| | Displaced Water, $W_s + W_{bw} - W_{bws}$ | <u>40.22</u> | | |
| Correction Factor | K | <u>.9995</u> | | |
| $(W_s K) \div (W_s + W_{bw} - W_{bws})$ | G_s | <u>2.14</u> | | |
| APPARENT (G_a) AND BULK (G_m) SPECIFIC GRAVITY | | | Temp. | Corr. Factor |
| Sample No. | | | $^{\circ}C$ | K |
| Temperature of Water and Soil, T , $^{\circ}C$ | | | <u>14</u> | <u>1.0010</u> |
| Wt. in grams | Pan + Saturated Surface - Dry Soil | | <u>15</u> | <u>1.0009</u> |
| | Tare Weight | | <u>16</u> | <u>1.0007</u> |
| | Saturated Surface - Dry Soil | <u>B</u> | <u>17</u> | <u>1.0006</u> |
| | (Wire Basket + Soil) in Water | | <u>18</u> | <u>1.0004</u> |
| | Wire Basket in Water | | <u>19</u> | <u>1.0002</u> |
| | Saturated Soil in Water | <u>C</u> | <u>20</u> | <u>1.0000</u> |
| | Tare Weight + Dry Soil | | <u>21</u> | <u>0.9998</u> |
| | Tare Weight | | <u>22</u> | <u>0.9996</u> |
| | Dry Soil | <u>A</u> | <u>23</u> | <u>0.9993</u> |
| Correction Factor | K | | <u>24</u> | <u>0.9991</u> |
| $(AK) \div (A-C)$ (Apparent) | G_a | | <u>25</u> | <u>0.9988</u> |
| $(AK) \div (B-C)$ (Bulk) | G_m | | <u>26</u> | <u>0.9985</u> |
| Remarks: <u>ALL - FILL</u> | | | <u>27</u> | <u>0.9983</u> |
| | | | <u>28</u> | <u>0.9980</u> |
| | | | <u>29</u> | <u>0.9977</u> |
| | | | <u>30</u> | <u>0.9974</u> |
| | | | <u>31</u> | <u>0.9971</u> |
| Tested by: <u>BC</u> | Computed by: <u>BC</u> | Checked by: <u>C</u> | | |

ATTACHMENT D
CONSOLIDATION TESTS
FOR HORIZONTAL PERMEABILITIES

JOB Bureau Engineering

JOB NO. 5651-013-07

DATE SAMPLED _____

BORING NO. TP1#1

TEST STARTED 5-18-67 BY PAB TEST FINISHED 5-18-67 BY PAB

DEPTH 2.0

SOIL TYPE CL (L) SL (L) SL (L) (L) - (L)

CONSOLIDOMETER NO. 2

INITIAL SAMPLE HEIGHT 1.2 in.

| MOISTURE & DENSITY DATA | BEFORE TEST | AFTER TEST |
|---------------------------------------|-------------|------------|
| WT. OF RING(S) + SOIL | 199.5 | 200.7 |
| WT. OF RING(S) ONLY | 45.1 | 45.1 |
| WT. OF SOIL (NET) | 154.4 | 155.6 |
| WET DENSITY IN LBS/CU. FT. | 121.3 | 120.3 |
| WT. OF WET SOIL + DISH NO. <u>372</u> | 193.2 | 200.7 |
| INT. OF DRY SOIL + DISH | 176.1 | 171.7 |
| WT. OF LOST MOISTURE | 23.6 | 23.0 |
| WT. OF DISH ONLY | 56.3 | 45.1 |
| WT. OF DRY SOIL | 113.8 | 124.1 |
| MOISTURE AS % OF DRY WT. | 20.7 | 23.0 |
| DRY DENSITY IN LBS/CU. FT. | 106.3 | 105.1 |

TEST INSTRUCTIONS

LOAD CYCLE _____

SPECIAL INSTRUCTION AND NOTES

① Vertical load only
 ② No lateral load
 ③ No lateral displacement
 ④ No lateral displacement

| DATE | TIME | E-LAPSED TIME IN MINS. | LOAD (PSF) | DIAL READING (0.001 IN.) | CONSOL. UNDER THIS LOAD | TOTAL CONSOL. (0.001 IN.) |
|---------|------|------------------------|------------|--------------------------|-------------------------|---------------------------|
| 5-18-67 | | | 0 | | | |
| | 1355 | | | 5100 | | |
| | | | 100 | | | |
| | 1356 | | | 5085 | | 0015 |
| | | | SAT | | | |
| | | | | 5086 | 0.2 | |
| | | | 200 | | | |
| | 1358 | | | 5083 | | 0017 |
| | | | | 5084 | 0.4 | |
| | | | 400 | | | |
| | 1359 | | | 5075 | | 0025 |
| | | | | 5076 | 0.4 | |
| | | | 800 | | | |
| | 1400 | | | 5071 | | 0029 |
| | 1404 | | | 5072 | 1.0 | |
| | | | 1600 | | | |
| | 1405 | | | 5052 | | |
| | 1406 | | | 5053 | | 0042 |
| | 1511 | | | 5053 | 2.0 | |
| | | | 3200 | | | |
| | 1512 | | | 5025 | | |
| | 1705 | | | 5013 | | |
| 5-19 | 220 | | | 5010 | | 0090 |
| | | | 6400 | | | |
| | 1005 | 0 | | 5010 | | |
| | | 6 | | 4975 | | |
| | | 15 | | 4961 | | |
| | | 20 | | 4950 | | |
| | 1006 | 1 | | 4950 | | |
| | 1007 | 2 | | 4950 | | |

| DATE | TIME | E-LAPSED TIME IN MINS. | LOAD (PSF) | DIAL READING (0.001 IN.) | CONSOL. UNDER THIS LOAD | TOTAL CONSOL. (0.001 IN.) |
|------|------|------------------------|------------|--------------------------|-------------------------|---------------------------|
| | 1009 | 4 | | 4953 | | |
| | 1014 | 9 | | 4950 | | |
| | 1020 | 15 | | 4947 | | |
| | 1035 | 30 | | 4947 | | |
| | 1105 | 60 | | 4946 | | |
| | 1205 | 120 | | 4944 | | |
| | 1405 | 240 | | 4942 | | 5100 |
| | 1805 | 480 | | 4941 | | 4920 |
| 5-20 | 1005 | 1440 | | 4939 | | 0161 |
| | | | 12800 | | | |
| | 1005 | 0 | | 4939 | | |
| | | 6 | | 4933 | | |
| | | 15 | | 4935 | | |
| | | 20 | | 4936 | | |
| | 1006 | 1 | | 4933 | | |
| | 1007 | 2 | | 4932 | | |
| | 1009 | 4 | | 4932 | | |
| | 1014 | 9 | | 4937 | | |
| | 1020 | 15 | | 4934 | | |
| | 1035 | 30 | | 4932 | | |
| | 1105 | 60 | | 4930 | | |
| | 1205 | 120 | | 4930 | | |
| | 1405 | 240 | | 4935 | | 5100 |
| | 1805 | 480 | | 4933 | | 4930 |
| 5-21 | 0900 | | | 4933 | | 0000 |

*MULTIPLY WEIGHT OF SOIL IN GRAMS BY 0.832 WHEN ONE STANDARD D & M SAMPLE IS USED.
 CONTINUED ON REVERSE SIDE

WORK SHEET - SPECIFIC GRAVITY TESTS

| | | | | | | | | |
|---|---|-------------------------|--------|-------------------------------|--|--------------------|--------------|--------|
| Project: <u>Dawson Engr. Co.</u> | | Job No. <u>5651-003</u> | | Hole No. <u>TP-1</u> | | Date <u>5/2/67</u> | | |
| SPECIFIC GRAVITY OF SOLIDS (G_s) | | | | | | | | |
| Sample No. | | 1 | | at 3-5 | | | | |
| Flask No. | | B | | | | | | |
| Temperature of Water and Soil, T , $^{\circ}\text{C}$ | | 22.5 | | | | | | |
| Pan No. | | | | | | | | |
| Wt. in grams | Pan + Dry Soil | | 440.30 | | | | | |
| | Pan | | 320.21 | | | | | |
| | Dry Soil | W_s | 120.06 | | | | | |
| | Flask + Water at T , $^{\circ}\text{C}$ | W_{bw} | 663.60 | | | | | |
| | $W_s + W_{bw}$ | | 783.66 | | | | | |
| | Flask + Water + Immersed Soil | W_{bws} | 721.07 | | | | | |
| | Displaced Water, $W_s + W_{bw} - W_{bws}$ | | 62.59 | | | | | |
| Correction Factor | | K | .9994 | | | | | |
| $(W_s K) \div (W_s + W_{bw} - W_{bws})$ | | G_s | 1.21 | | | | | |
| APPARENT (G_a) AND BULK (G_m) SPECIFIC GRAVITY | | | | | | Temp. | Corr. Factor | |
| Sample No. | | | | | | $^{\circ}\text{C}$ | K | |
| Temperature of Water and Soil, T , $^{\circ}\text{C}$ | | | | | | 14 | 1.0010 | |
| Wt. in grams | Pan + Saturated Surface - Dry Soil | | | | | | 15 | 1.0009 |
| | Tare Weight | | | | | | 16 | 1.0007 |
| | Saturated Surface - Dry Soil | B | | | | | 17 | 1.0006 |
| | (Wire Basket + Soil) in Water | | | | | | 18 | 1.0004 |
| | Wire Basket in Water | | | | | | 19 | 1.0002 |
| | Saturated Soil in Water | C | | | | | 20 | 1.0000 |
| | Tare Weight + Dry Soil | | | | | | 21 | 0.9998 |
| | Tare Weight | | | | | | 22 | 0.9996 |
| | Dry Soil | A | | | | | 23 | 0.9993 |
| Correction Factor | | K | | | | | 24 | 0.9991 |
| $(AK) \div (A-C)$ (Apparent) | | G_a | | | | | 25 | 0.9988 |
| $(AK) \div (B-C)$ (Bulk) | | G_m | | | | | 26 | 0.9986 |
| Remarks: ML - Full | | | | | | 27 | 0.9983 | |
| | | | | | | 28 | 0.9980 | |
| | | | | | | 29 | 0.9977 | |
| | | | | | | 30 | 0.9974 | |
| | | | | | | 31 | 0.9971 | |
| Tested by: <u>BC</u> | | Computed by: <u>BC</u> | | Checked by: <u> </u> | | | | |

| DATE | TIME | E-LAPSED TIME IN MINS. | LOAD (PSF) | DIAL READING (1000 IN.) | CONSOL. UNDER THIS LOAD | TOTAL CONSOL. LOCATION |
|---------|-------|------------------------|------------|-------------------------|-------------------------|------------------------|
| 5-21-57 | | 5200 | Continued | | | |
| | 12:50 | 240 | | 4430 | | 4653 |
| | 1750 | 450 | | 4427 | | 4425 |
| 5-22 | 0920 | 120 | | 4425 | | 0222 |
| | | | 6400 | | | |
| | 0950 | 0 | | 4425 | | |
| | | 6 | | 4345 | | |
| | | 15 | | 4341 | | |
| | | 20 | | 4339 | | |
| | 0951 | 1 | | 4331 | | |
| | 0952 | 2 | | 4327 | | |
| | 0954 | 4 | | 4324 | | |
| | 0959 | 9 | | 4322 | | |
| | 1005 | 15 | | 4321 | | |
| | 1020 | 20 | | 4319 | | |
| | 1050 | 60 | | 4317 | | |
| | 1145 | 120 | | 4315 | | |
| | 1252 | 240 | | 4313 | | 4653 |
| | 1750 | 450 | | 4310 | | 4307 |
| 5-23 | 0950 | 1440 | | 4307 | | 0346 |
| | | | 12,800 | | | |
| | 0950 | 0 | | 4307 | | |
| | | 6 | | 4161 | | |
| | | 15 | | 4154 | | |
| | | 30 | | 4150 | | |
| | 0951 | 1 | | 4146 | | |
| | 0952 | 2 | | 4143 | | |
| | 0954 | 4 | | 4130 | | |
| | 0959 | 9 | | 4137 | | |
| | 1005 | 15 | | 4135 | | |
| | 1020 | 20 | | 4132 | | |
| | 1050 | 60 | | 4130 | | |
| | 1750 | 180 | | 4126 | | |
| | 1250 | 300 | | 4124 | | 4653 |
| | 1750 | 450 | | 4122 | | 4118 |
| 9-24 | 0950 | 1440 | | 4119 | | 0335 |
| | | | 25,600 | | | |
| | 0950 | 0 | | 4119 | | |
| | | 6 | | 3896 | | |
| | | 15 | | 3888 | | |
| | | 30 | | 3882 | | |
| | 0951 | 1 | | 3877 | | |
| | 0952 | 2 | | 3872 | | |
| | 0954 | 4 | | 3867 | | |
| | 0959 | 9 | | 3863 | | |
| | 1005 | 15 | | 3860 | | |
| | 1020 | 20 | | 3856 | | |
| | 1050 | 60 | | 3853 | | |
| | 1150 | 120 | | 3850 | | |
| | 1350 | 240 | | 3846 | | 4653 |
| | 1750 | 450 | | 3845 | | 3832 |
| 9-25 | 0950 | 1440 | | 3838 | | 0315 |

| DATE | TIME | E-LAPSED TIME IN MINS. | LOAD (PSF) | DIAL READING (1000 IN.) | CONSOL. UNDER THIS LOAD | TOTAL CONSOL. LOCATION |
|------|------|------------------------|------------|-------------------------|-------------------------|------------------------|
| 5-25 | | | 51200 | | | |
| | 0950 | 0 | | 3824 | | |
| | | 6 | | 3524 | | |
| | | 15 | | 3512 | | |
| | | 30 | | 3506 | | |
| | 0951 | 1 | | 3497 | | |
| | 0952 | 2 | | 3490 | | |
| | 0954 | 4 | | 3490 | | |
| | 0959 | 9 | | 3481 | | |
| | 1005 | 15 | | 3473 | | |
| | 1020 | 20 | | 3468 | | |
| | 1050 | 60 | | 3463 | | |
| | 1150 | 120 | | 3459 | | |
| | 1350 | 240 | | 3455 | | 11,500 |
| | 1750 | 450 | | 3452 | | 2000 |
| 5-26 | 0950 | 1440 | | 3445 | | 1,000 |
| | | | 102,600 | | | |
| | 0950 | 0 | | 3425 | | |
| | | 6 | | 3041 | | |
| | | 15 | | 3022 | | |
| | | 30 | | 3010 | | |
| | 0951 | 1 | | 2999 | | |
| | 0952 | 2 | | 2990 | | |
| | 0954 | 4 | | 2982 | | |
| | 0959 | 9 | | 2972 | | |
| | 1005 | 15 | | 2963 | | |
| | 1020 | 20 | | 2952 | | |
| | 1050 | 60 | | 2956 | | |
| | 1150 | 120 | | 2951 | | |
| | 1350 | 240 | | 2946 | | |
| | 1750 | 450 | | 2942 | | |
| 5-27 | 0950 | 1440 | | | | |
| | | | 100 | | | |
| | 1751 | | | 3815 | | |

WORK SHEET - SPECIFIC GRAVITY TESTS

Project: BRUNN ENGR. Co. Job No. 651-003 Hole No. 102 Date 5/21/67

SPECIFIC GRAVITY OF SOLIDS (G_s)

| | | | | | |
|---|------------------|--------|--|--|--|
| Sample No. | 1 | 27.3.6 | | | |
| Flask No. | D. | | | | |
| Temperature of Water and Soil, T, °C | 22.5 | | | | |
| Pan No. | | | | | |
| Pan + Dry Soil | 351.12 | | | | |
| Pan | 60.20 | | | | |
| Dry Soil | W_s 93.95 | | | | |
| Flask + Water at T, °C | W_{bw} 643.66 | | | | |
| $W_s + W_{bw}$ | 142.51 | | | | |
| Flask + Water + Immersed Soil | W_{bws} 705.20 | | | | |
| Displaced Water, $W_s + W_{bw} - W_{bws}$ | 24.31 | | | | |
| Correction Factor | K 0.9995 | | | | |
| $(W_s K) \div (W_s + W_{bw} - W_{bws})$ | G_s 2.73 | | | | |

APPARENT (G_a) AND BULK (G_m) SPECIFIC GRAVITY

Temp. Corr. Factor

| | | | | | |
|--------------------------------------|-------|--|--|----|--------|
| Sample No. | | | | °C | K |
| Temperature of Water and Soil, T, °C | | | | 14 | 1.0010 |
| Pan + Saturated Surface - Dry Soil | | | | 15 | 1.0009 |
| Tare Weight | | | | 16 | 1.0007 |
| Saturated Surface - Dry Soil | B | | | 17 | 1.0006 |
| (Wire Basket + Soil) in Water | | | | 18 | 1.0004 |
| Wire Basket in Water | | | | 19 | 1.0002 |
| Saturated Soil in Water | C | | | 20 | 1.0000 |
| Tare Weight + Dry Soil | | | | 21 | 0.9998 |
| Tare Weight | | | | 22 | 0.9996 |
| Dry Soil | A | | | 23 | 0.9993 |
| Correction Factor | K | | | 24 | 0.9991 |
| $(AK) \div (A-C)$ (Apparent) | G_a | | | 25 | 0.9988 |
| $(AK) \div (B-C)$ (Bulk) | G_m | | | 26 | 0.9985 |
| Remarks: | | | | 27 | 0.9983 |
| | | | | 28 | 0.9980 |
| | | | | 29 | 0.9977 |
| | | | | 30 | 0.9974 |
| | | | | 31 | 0.9971 |

VI-70

Tested by: BCComputed by: BCChecked by: BC

ATTACHMENT E

SUPPLEMENTARY MOISTURE - DENSITY TESTS

MOISTURE AND DENSITY DETERMINATIONS

DAMES & MOORE

CLIENT BAUER ENGINEERING

JOB NO. 5451-653

LOCATION ORANGE COUNTY, VIRGINIA

PAGE 1 OF 3

| 1 | 1 | 2 | 2 | 2 | 2 | 2 |
|-------|-------|--------------------------|-------|-------|---|---|
| 5A | 5B | 1A | 1C | 3A | | |
| 10.0 | 11.0 | 1.5 | 2.0 | 7.0 | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| 4 | 3 | THIN WALL HEIGHT=5.0" | 3 | 4 | | |
| 747 | 598 | | 542 | 721 | | |
| 180 | 135 | | 135 | 180 | | |
| | | 743.5 | | | | |
| 118.0 | 128.4 | 123.2 | 112.8 | 112.4 | | |
| 94 | 107 | 101 | 88 | 91 | | |
| P | IV | 26 | 24 | 2-13 | | |
| 151.0 | 167.9 | 144.5 | 132.0 | 149.9 | | |
| 125.5 | 144.0 | 122.2 | 107.5 | 124.5 | | |
| 25.5 | 23.9 | 22.3 | 21.5 | 25.4 | | |
| 24.3 | 24.5 | 22.4 | 22.4 | 20.3 | | |
| 101.2 | 119.5 | 99.8 | 85.1 | 101.2 | | |
| 25.2 | 20.0 | 22.4 | 28.8 | 21.4 | | |

| BORING | 1 | 1 |
|------------------------------|-------|-------|
| SAMPLE NO. | 1B | AA |
| SAMPLE DEPTH | 1.5 | 8.5 |
| DATE SAMPLED BY | JBR | |
| DATE TESTED BY | MRR | |
| SOIL TYPE | | |
| LABORATORY IDENTIFICATION | | |
| NO OF RINGS | 6 | 6 |
| WT. OF WET SOIL & RINGS | 1141 | 1131 |
| WT. OF RINGS | 270 | 270 |
| WT. OF WET SOIL | | |
| WET DENSITY (LBS./CU.FT.) | 120.9 | 119.5 |
| DRY DENSITY (LBS./CU.FT.) | 97 | 95 |
| DISH NO. | 25 | V |
| WT. OF WET SOIL & DISH | 180.1 | 157.5 |
| WT. OF DRY SOIL & DISH | 149.0 | 130.0 |
| NET LOSS OF MOISTURE | 31.1 | 27.5 |
| WT. OF DISH | 22.5 | 24.4 |
| WT. OF DRY SOIL | 126.5 | 105.6 |
| MOISTURE CONTENT (% DRY WT.) | 24.7 | 26.0 |

CLIENT

JOB NO. 5651-003

LOCATION

PAGE 2 OF 3

| SAMPLE & SOIL TYPE | | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
|------------------------------|-----|-------|-------|-------|-------|-------|-------|-------|-------|---|---|---|
| BORING | | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| SAMPLE NO. | | 4 | 5A | 5B | 18 | 2A | 3A | 3B | 4B | | | |
| SAMPLE DEPTH | | 9.0 | 11.5 | 11.7 | 1.0 | 3.5 | 6.5 | 6.8 | 8.5 | | | |
| DATE SAMPLED BY | JAR | 5-12 | | | | | | | | | | |
| DATE TESTED BY | MRA | 5-17 | | | | | | | | | | |
| SOIL TYPE | | | | | | | | | | | | |
| LABORATORY IDENTIFICATION | | | | | | | | | | | | |
| NO. OF RINGS | | 5 | 6 | 4 | 4 | 4 | 2 | 6 | 4 | 3 | | |
| WT. OF WET SOIL & RINGS | | 912 | 1231 | 728 | 722 | 381 | 1203 | 737 | 585 | | | |
| WT. OF RINGS | | 225 | 270 | 180 | 180 | 90 | 270 | 100 | 135 | | | |
| WT. OF WET SOIL | | | | | | | | | | | | |
| WET DENSITY (LBS./CU.FT.) | | 114.3 | 133.3 | 114.0 | 112.8 | 120.9 | 129.5 | 116.0 | 124.8 | | | |
| DRY DENSITY (LBS./CU.FT.) | | 93 | 101 | 86 | 94 | 101 | 108 | 96 | 113 | | | |
| DISH NO. | | 2-10 | 4 | V | 20 | N | 18 | G | 17 | | | |
| WT. OF WET SOIL & DISH | | 133.5 | 137.5 | 171.9 | 155.9 | 152.0 | 164.3 | 135.1 | 143.8 | | | |
| WT. OF DRY SOIL & DISH | | 111.9 | 109.0 | 135.0 | 133.5 | 131.0 | 139.9 | 115.5 | 132.2 | | | |
| NET LOSS OF MOISTURE | | 21.6 | 28.5 | 36.9 | 22.4 | 21.0 | 24.4 | 19.6 | 11.6 | | | |
| WT. OF DISH | | 21.0 | 21.5 | 24.5 | 20.9 | 24.7 | 21.5 | 21.8 | 22.3 | | | |
| WT. OF DRY SOIL | | 90.9 | 87.5 | 110.5 | 112.6 | 106.3 | 118.4 | 93.7 | 109.9 | | | |
| MOISTURE CONTENT (% DRY WT.) | | 23.8 | 32.6 | 33.4 | 19.9 | 19.8 | 20.6 | 20.9 | 10.1 | | | |

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MOISTURE AND DENSITY DETERMINATIONS

DAMES & MOORE

CLIENT

JOB NO. 5651-443...

LOCATION

PAGE 3 OF 3

| BORING | SAMPLE NO. | SAMPLE DEPTH | DATE SAMPLED BY | DATE TESTED BY | SOIL TYPE | LABORATORY IDENTIFICATION |
|------------------------------|------------|--------------|-----------------|----------------|-----------|---------------------------|
| 3 | 5 | 11.0 | JBR | 5-17 | | |
| 6B | 8A | 18.5 | 18.7 | 9A | 21.4 | 22.0 |
| 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| WT. OF WET SOIL & RINGS | 373 | 598 | 1190 | 747 | 1026 | 1267 |
| WT. OF RINGS | 90 | 135 | 270 | 180 | 225 | 270 |
| WT. OF DRY SOIL | | | | | | |
| WET DENSITY (LBS./CU.FT.) | 117.5 | 128.5 | 127.4 | 116.8 | 133.2 | 138.3 |
| DRY DENSITY (LBS./CU.FT.) | 96 | 105 | 104 | 97 | 116 | 121 |
| DISH NO. | M | N | III | I | VIII | E |
| WT. OF WET SOIL & DISH | 140.5 | 111.2 | 165.0 | 153.1 | 176.9 | 155.0 |
| WT. OF DRY SOIL & DISH | 119.3 | 95.5 | 139.2 | 121.1 | 157.5 | 139.5 |
| NET LOSS OF MOISTURE | 21.2 | 15.7 | 25.8 | 32.0 | 19.4 | 16.5 |
| WT. OF DISH | 25.4 | 24.2 | 25.0 | 25.0 | 25.2 | 22.2 |
| WT. OF DRY SOIL | 93.9 | 71.3 | 114.2 | 106.1 | 132.3 | 117.3 |
| MOISTURE CONTENT (% DRY WT.) | 22.6 | 22.1 | 22.6 | 20.8 | 14.5 | 14.1 |

ATTACHMENT F
COMPACTION TEST DATA
AASHTO T 180-57

F-1

COMPACTION TEST DATA

AASHTO T 180-57

TEST PIT 1 @ A DEPTH OF 8.0 FEET
IN-SITU MOISTURE CONTENT = 24.1%

| <u>DRY DENSITY</u> <u>LBS./CU. FT.</u> | <u>MOISTURE CONTENT</u> <u>PERCENT</u> |
|---|---|
| 104.2 | 7.2 |
| 111.8 | 11.4 |
| 113.1 | 13.0 |
| 113.6 | 14.4 |
| 113.4 | 15.0 |
| 111.2 | 17.3 |
| 98.7 | 24.1 |
| 93.8 | 26.9 |

TEST PIT 2 @ A DEPTH OF 6.0 FEET
IN-SITU MOISTURE CONTENT = 16.3%

| <u>DRY DENSITY</u> <u>LBS./CU. FT.</u> | <u>MOISTURE CONTENT</u> <u>PERCENT</u> |
|---|---|
| 107.6 | 6.0 |
| 111.0 | 8.4 |
| 113.7 | 11.4 |
| 114.1 | 13.1 |
| 113.0 | 15.5 |
| 106.9 | 19.9 |

F-2

COMPACTION TEST DATA (CONT'D.)

AASHTO T 180-57

BORROW AREA

IN-SITU MOISTURE CONTENT - NOT DETERMINED

DRY DENSITY
LBS./CU. FT.

MOISTURE CONTENT
PERCENT

114.0

9.5

115.2

12.0

115.3

12.8

113.8

15.5

108.4

17.9

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ATTACHMENT G
ATTERBERG LIMITS AND GRAIN SIZE ANALYSES

G-1

ATTERBERG LIMITS

| <u>LOCATION</u> | <u>DEPTH FEET</u> | <u>LIQUID LIMIT PERCENT</u> | <u>PLASTIC LIMIT PERCENT</u> | <u>PLASTICITY INDEX</u> |
|-----------------|-----------------------|---------------------------------|----------------------------------|-----------------------------|
| Boring 1 | 1.5 | 47 | 41 | 6 |
| Boring 2 | 4.5 | 42 | 34 | 8 |
| Boring 2 | 7.0 | 44 | 36 | 8 |
| Boring 3 | 6.5 | 41 | 38 | 3 |
| Boring 3 | 13.5 | 37 | 32 | 5 |
| Boring 3 | 18.5 | 42 | 34 | 8 |
| Test Pit 1 | 8.0 | 43 | 35 | 8 |
| Test Pit 2 | 6.0 | 36 | 35 | 1 |
| Borrow Area | --- | 34 | 32 | 2 |

G-2

GRAIN SIZE ANALYSES

| <u>LOCATION</u> | | Boring 2 | Boring 3 |
|---|-----------------------------------|--|--|
| <u>DEPTH - FEET</u> | | 4.5 | 13.5 |
| <u>U.S. STANDARD</u> <u>SIEVE SIZE</u> | <u>SIEVE OPENING</u> <u>MM</u> | <u>PERCENT</u> <u>FINER</u> <u>BY WEIGHT</u> | <u>PERCENT</u> <u>FINER</u> <u>BY WEIGHT</u> |
| No. 10 | 2.00 | 100.0 | 100.0 |
| No. 16 | 1.19 | 96.4 | 96.9 |
| No. 20 | 0.841 | 94.6 | 95.1 |
| No. 40 | 0.420 | 89.5 | 89.6 |
| No. 50 | 0.297 | 86.8 | 86.1 |
| No. 60 | 0.250 | 85.7 | 84.9 |
| No. 100 | 0.149 | 81.0 | 80.2 |
| No. 140 | 0.105 | 77.1 | 77.1 |
| No. 200 | 0.074 | 73.6 | 74.4 |
| No. 325 | 0.044 | 67.2 | 70.4 |
| ---- | 0.020 | 34.9 | 30.7 |
| ---- | 0.005 | 9.1 | 5.1 |
| ---- | 0.001 | 0.1 | 1.2 |

GRAIN SIZE ANALYSES

| <u>LOCATION</u> | | Test Pit 1 | Test Pit 2 | Borrow Area |
|---|-----------------------------------|--|--|--|
| <u>DEPTH - FEET</u> | | 8.0 | 6.0 | ----- |
| <u>U.S. STANDARD</u> <u>SIEVE SIZE</u> | <u>SIEVE OPENING</u> <u>MM</u> | <u>PERCENT</u> <u>FINER</u> <u>BY WEIGHT</u> | <u>PERCENT</u> <u>FINER</u> <u>BY WEIGHT</u> | <u>PERCENT</u> <u>FINER</u> <u>BY WEIGHT</u> |
| No. 10 | 2.00 | 100.0 | 100.0 | 100.0 |
| No. 16 | 1.19 | 97.2 | 96.3 | 97.2 |
| No. 20 | 0.841 | 95.0 | 92.4 | 93.8 |
| No. 40 | 0.420 | 90.0 | 82.7 | 81.5 |
| No. 50 | 0.297 | 87.1 | 78.1 | 75.2 |
| No. 60 | 0.250 | 85.7 | 76.1 | 72.7 |
| No. 100 | 0.149 | 79.8 | 69.9 | 65.3 |
| No. 140 | 0.105 | 75.0 | 67.6 | 61.1 |
| No. 200 | 0.074 | 71.2 | 64.3 | 58.7 |
| No. 325 | 0.044 | 65.9 | 57.1 | 50.7 |
| ----- | 0.020 | 38.2 | 24.6 | 18.2 |
| ----- | 0.005 | 11.3 | 2.3 | 1.1 |
| ----- | 0.001 | 0.2 | 0.1 | 0.0 |

APPENDIX VII

STABILITY ANALYSIS

REPORT - SOILS ENGINEERING SERVICES

**PROPOSED DAM - LAKE OF THE WOODS RESERVOIR
ORANGE COUNTY, VIRGINIA**

FOR

BAUER ENGINEERING, INC.

5651-002-07



DAMES & MOORE

CONSULTANTS IN APPLIED EARTH SCIENCES
SOIL MECHANICS • ENGINEERING GEOLOGY • GEOPHYSICS

ATLANTA NEW YORK
CHICAGO PORTLAND
HONOLULU SALT LAKE CITY
HOUSTON SAN FRANCISCO
LOS ANGELES SEATTLE
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PARTNERS: JAMES B. THOMPSON • GEORGE D. LEAL

ASSOCIATE: WILLIAM G. PARATORE

January 31, 1967

Bauer Engineering, Inc.
20 North Wacker Drive
Chicago, Illinois 60606

Attention: Mr. William J. Bauer

Gentlemen:

i Report - Soils Engineering Services
Proposed Dam - Lake of the Woods Reservoir
Orange County, Virginia
For Bauer Engineering, Inc.

This letter presents the results of our Soils Engineering Services performed in connection with the Proposed Dam - Lake of the Woods Reservoir to be constructed in Orange County, Virginia.

The scope of our Soils Engineering Services was planned in collaboration with Messrs. William J. Bauer and Robert L. Hall of Bauer Engineering, Inc. Soil strength parameters of proposed fill soils were provided to Bauer Engineering, Inc. on January 11, 1967. The results of our stability analyses were provided on January 12, 1967. An estimated coefficient of permeability equal to 0.2 feet per year for Material II compacted to 90 percent of the maximum dry density as determined in accordance with the AASHTO T 180-57 Method of Compaction, was provided on January 23, 1967.

VII-1

CABLE ADDRESS: DAMEMORE

The scope of our soils engineering services was as follows:

- 1 - The performance of laboratory tests to determine the strength characteristics of the remoulded compacted fill soils to be used to construct the Proposed Dam. The compacted fill soils were evaluated at the following density criteria: (a) 90 percent of the maximum dry density as determined in accordance with AASHO T 180-57 Method of Compaction, (b) 95 percent of the maximum dry density as determined in accordance with the ASTM D 698 Method of Compaction, and (c) 90 percent of the maximum dry density as determined in accordance with ASTM D 698 Method of Compaction. The laboratory strength tests consisted of triaxial tests and direct shear tests.
- 2 - Engineering analyses to evaluate the stability of two proposed dam embankments. One dam embankment is to consist entirely of soil compacted to 90 percent of the maximum dry density as determined in accordance with the AASHO T 180-57 Method of Compaction. The other embankment, as proposed by the Contractor, is to consist of a core approximately 50 feet wide, located near the center of the dam, compacted to 95 percent of the maximum dry density as determined in accordance with ASTM D 698 Method of Compaction. The soil to be placed on each side of the core will be compacted to 90 percent of the maximum dry density as determined in accordance with ASTM D 698 Method of Compaction. Both proposed embankments will have an upstream slope of one vertical to four horizontal and a downstream slope of one vertical to three horizontal.

- 3 - Additional engineering analyses, if required, for the proposed embankment consisting entirely of soil compacted to 90 percent of the maximum dry density as determined in accordance with AASHTO T 180-57 Method of Compaction will be performed to determine the optimum design cross section with respect to slope stability and economy of known materials.

INTRODUCTION:

Representative bulk samples of the proposed borrow materials were obtained by our field engineer on December 20, 1966 from test pits excavated in the Proposed Borrow Pit. Test pit locations were established by Bauer Engineering, Inc.

The soil profile in the Proposed Borrow Pit area is similar to the soil profiles presented in our "Report of Soil Exploration, Proposed Dam - Lake of the Woods Reservoir, Orange County, Virginia for Bauer Engineering, Inc." dated October 21, 1966. The soils are residual in origin and were derived from the weathering of gneisses, schists, and other metamorphic rocks. The Proposed Borrow Pit is blanketed by topsoil and the topsoil is underlain by reddish brown silty clays, clayey silts, and silts with sand and clay which in turn are underlain by brown and gray sandy silts and sandy clays.

From visual inspection of the test pits and inspection of bulk samples in the laboratory, it was determined that the soils in the Proposed Borrow Pit consist essentially of three soil types. The three soil types and the coordinates of the respective test pits and depths at which bulk samples of the three soil types were obtained are as follows:

| | SOIL TYPE | COORDINATE OF TEST PITS | GROUND SURFACE | DEPTH OF BULK SAMPLE (FEET) |
|--------------|---|----------------------------|---------------------------------|--------------------------------|
| | | | ELEVATION AT TEST PIT (FEET) | |
| MATERIAL I | Reddish Brown Clayey Silt | K + 60 13 + 20 | 292 | 6 |
| MATERIAL II | Reddish Brown Silt with Sand and Clay | K + 60 13 + 20 | 292 | 11.5 |
| MATERIAL III | Brown Sandy Clay | L + 30 15 + 80 | 307 | 8 |

LABORATORY TESTS:

Two compaction tests were performed on each of the three soil types. One compaction test was performed in accordance with the AASHO T 180-57 Method of Compaction, and the second compaction test was performed in accordance with the ASTM D 698 Method of Compaction.

Remoulded samples of each soil type, compacted to 90 percent of the maximum dry density as determined in accordance with the AASHO T 180-57 Method of Compaction and to 95 percent and 90 percent of the maximum dry density as determined in accordance with the ASTM D 698 Method of Compaction, were then subjected to strength tests. The strength tests consisted of direct shear tests and undrained triaxial tests. The strength tests were performed on remoulded samples having a moisture content approximately equal to the anticipated fill moisture content at the time of placement and compaction of the fill and on saturated or near-saturated remoulded samples.

The Atterberg limits were determined for Materials I and II. Specific gravity determinations were performed on all three soil types and a grain size analysis was performed on Material II.

Laboratory test results are presented on Plates 1 and 2.

STABILITY ANALYSES:

Stability analyses were performed on the two proposed dam embankments. For each of the proposed dam embankments the stabilities of both upstream and downstream slopes were evaluated. The strength parameters used in the stability analyses were those of Material II. It is considered that the Proposed Dam will consist primarily of Material I and Material II. Material II has the lowest strength parameters of the three predominant soil types encountered in the Proposed Borrow Pit. It was judged advisable by Dames & Moore and Bauer Engineering, Inc. to use the lower of the strength parameters in the stability analyses. The phreatic line in both of the proposed dam embankments was assumed, for purposes of stability analyses, to be a straight line from the water level on the upstream slope to the filter drain. This assumption is based on a filter drain that is performing adequately. The soil on both the upstream and downstream slopes was assumed to be saturated. The proposed dam site is in a seismically active area and an earthquake loading equal to five percent of the acceleration due to gravity was utilized in the stability analyses.

The results of the stability analyses on the proposed homogeneous dam embankment consisting entirely of soil compacted to 90 percent of the maximum dry density as determined in accordance with the AASHO T 180-57 Method of Compaction are shown on Plate 3. The parameters of the foundation soil immediately underlying the dam embankment were assumed.

The results of the stability analyses on the proposed alternate dam embankment, as proposed by the Contractor, are shown on Plate 4.

This embankment contains a core approximately 50 feet wide compacted to 95 percent of the maximum dry density as determined in accordance with the ASTM D 698 Method of Compaction to 90 percent of the maximum dry density as determined in accordance with the ASTM D 698 Method of Compaction. Material II when compacted to 90 percent of the ASTM D 698 maximum dry density has a cohesion equal to zero and an angle of internal friction which is less than the slope angles of the embankment. Thus the side slopes of the embankment, as proposed by the Contractor, are unstable.

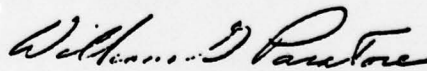
--oOo--

The following Plates are attached and complete this report:

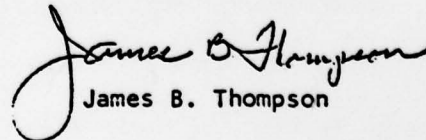
- Plate 1 - Summary of Laboratory Test Data
- Plate 2 - Gradation Curve of Material II
- Plate 3 - Results of Stability Analyses of Homogeneous
Dam Embankment
- Plate 4 - Results of Stability Analyses of Proposed Alternate
Dam Embankment.

Yours very truly,

DAMES & MOORE



William G. Paratore



James B. Thompson

WGP:JBT:DGS:ac
Ten Copies Submitted

| | | | | | | | | | |
|--|------------------------|------------------------|-------|-----|------|-----|----|------|----|
| MATERIAL I SAND 1-36 INDEX = 13 DENSITY = 279 | 912 PCF a 28.6 % | 847 PCF a 31.4 % | 30-50 | 83° | 906 | 119 | 36 | 400 | 15 |
| | | | | | | 1 | | | |
| | | | | | | 2 | | | 23 |
| | | | | | | 1 | | | 11 |
| MATERIAL II BROWN AND CLAY 1-53 INDEX = 6 DENSITY = 279 | | | | 78° | 758 | 102 | 35 | 400 | 22 |
| | | | | | | 2 | | | 8 |
| | | | | | | 1 | | | |
| | | | | | | 2 | | | 29 |
| MATERIAL III SAND 1-36 INDEX = 13 DENSITY = 279 | | | | 90 | 825 | 110 | 34 | 750 | 20 |
| | | | | | | 2 | | | 20 |
| | | | | | | 1 | | | |
| | | | | | | 2 | | | 24 |
| MATERIAL IV SAND 1-36 INDEX = 13 DENSITY = 279 | | | | 82° | 751 | 105 | 40 | 500 | 15 |
| | | | | | | 2 | | | 21 |
| | | | | | | 1 | | | |
| | | | | | | 2 | | | 13 |
| MATERIAL V SAND 1-36 INDEX = 13 DENSITY = 279 | | | | 78° | 715 | 108 | 51 | 0 | 26 |
| | | | | | | 2 | | | 19 |
| | | | | | | 1 | | | |
| | | | | | | 2 | | | 20 |
| MATERIAL VI SAND 1-36 INDEX = 13 DENSITY = 279 | | | | 90 | 1095 | 127 | 16 | 1200 | 19 |
| | | | | | | 2 | | | |
| | | | | | | 1 | | | |
| | | | | | | 2 | | | 20 |
| MATERIAL VII SAND 1-36 INDEX = 13 DENSITY = 279 | | | | 86° | 1045 | 124 | 19 | 700 | 19 |
| | | | | | | 2 | | | 20 |
| | | | | | | 1 | | | |
| | | | | | | 2 | | | 20 |
| MATERIAL VIII SAND 1-36 INDEX = 13 DENSITY = 279 | | | | 82° | 996 | 119 | 19 | 500 | 19 |
| | | | | | | 2 | | | |
| | | | | | | 1 | | | |
| | | | | | | 2 | | | 19 |

NOTES:
 1. VALUES TO SOIL IS UNCLASSIFIED
 2. VALUES TO ESTIMATED SOIL
 3. VALUES TO ESTIMATED SOIL

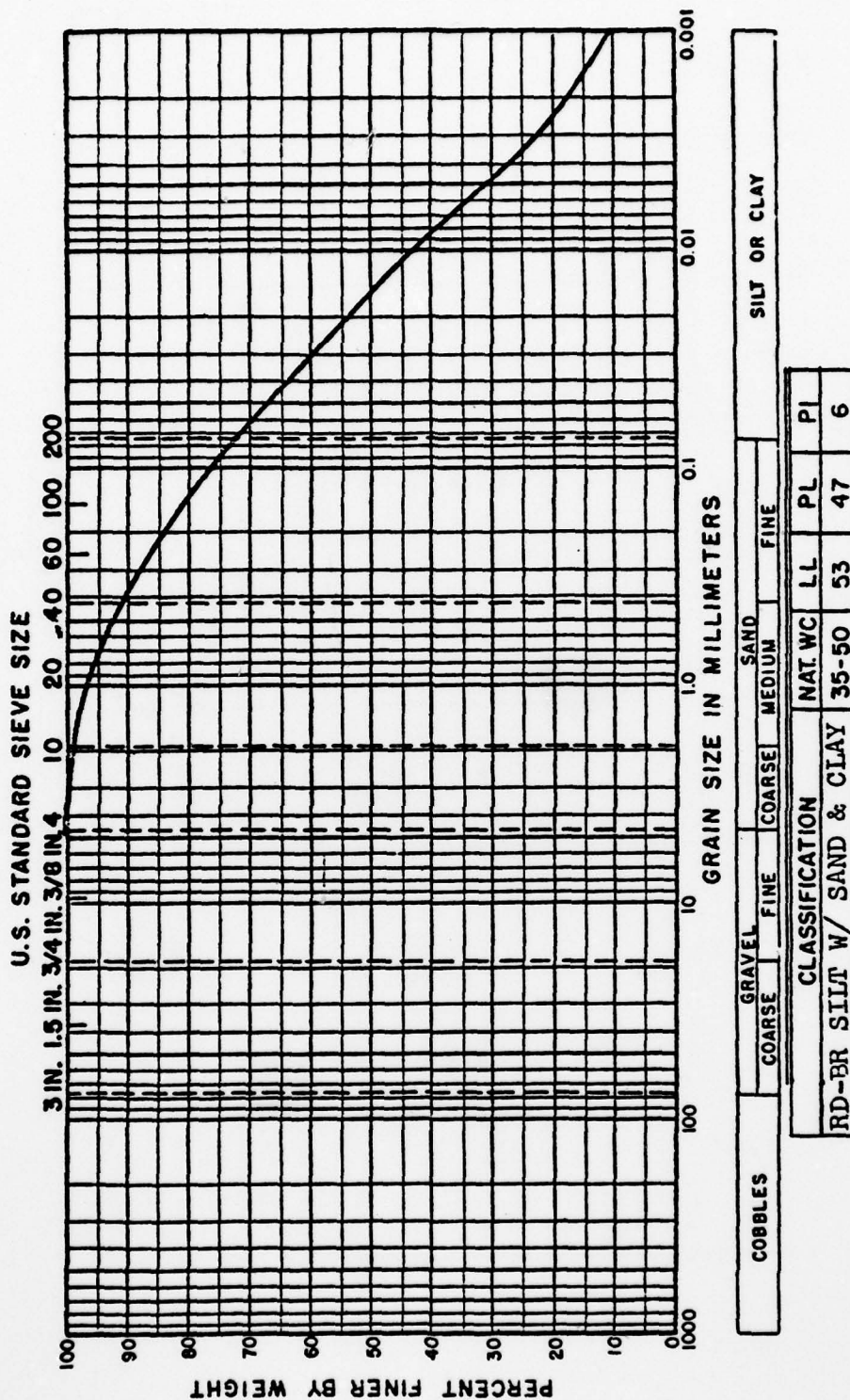
• 9/11/78
 • 1/11/78
 • 1/11/78

VII-7

SUMMARY OF LABORATORY TEST DATA

CHECKED BY _____ DATE _____

CHECKED BY _____ DATE _____



VII-8

DAMES & MOORE
APPLIED EARTH SCIENCES

PLATE 2

GRADATION CURVE FOR MATERIAL II

| | | |
|---|--------------------------------------|---|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT <u>Earth Dams: Stability</u> | PROJECT <u>Design Standards</u> |
| | COMPUTED <u>Bauer</u> | FILE NO. _____ |
| | CHECKED _____ | DATE <u>4-5-67</u> PAGE <u>1</u> OF _____ PAGES |

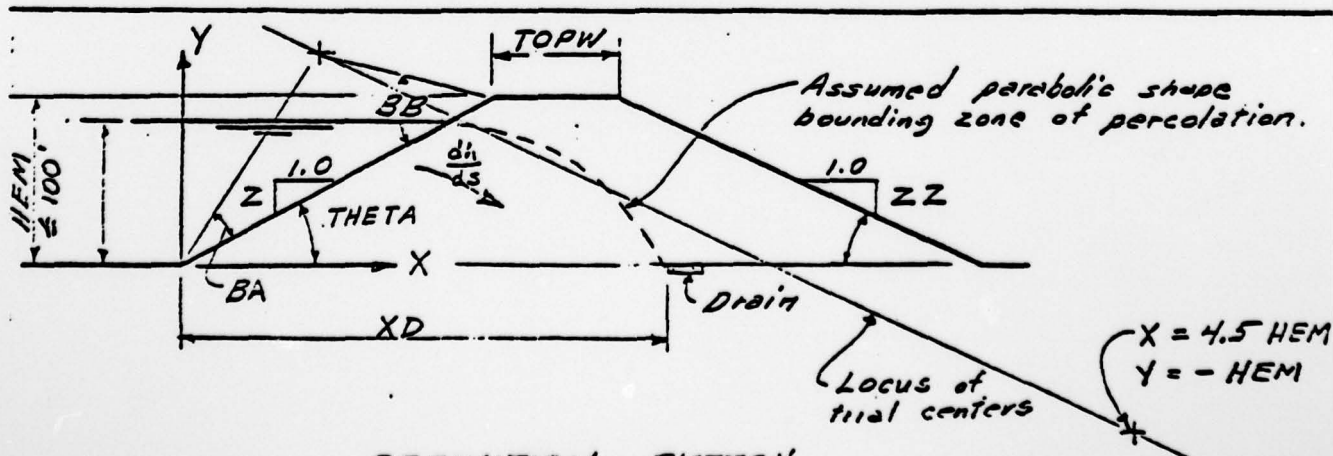
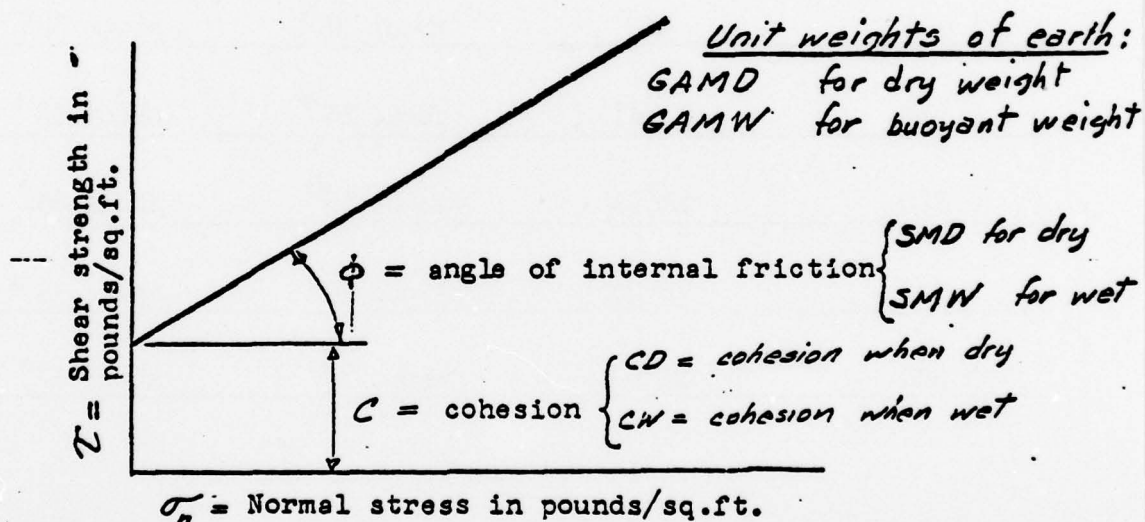
The purpose of this standard is to pull together the materials developed over a period of time regarding the design of earth dams as far as the stability of the slopes is concerned. Until superseded by another standard covering the same subject, this procedure will be used in the analysis of all earth dams which fall within the scope of this procedure.

Scope

under 100' in height

This standard procedure covers dams with the following characteristics:

1. The upstream and downstream slopes are uniform and approximately equal.
2. The foundation material is at least equal in strength to the compacted material comprising the embankment.
3. The strength of the material in shear may be described as a straight-line plot on a diagram as follows:



DEFINITION SKETCH

| | | |
|---|--------------------------------------|---|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT <u>Earth Dams: Stability</u> | PROJECT <u>Design Standard</u> |
| | COMPUTED <u>Bauer</u> | FILE NO. _____ |
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Locus of Trial Centers

The location of the center of the slip circle of least Factor of Safety may be estimated with the aid of the Locus of Trial Centers shown on the Definition Sketch, which was obtained from Jumikis, Soil Mechanics, page 698. The values of angles BA and BB are estimated with the aid of the following table:

| <u>Z</u> | <u>THETA</u> | <u>BA</u> | <u>BB</u> |
|----------|--------------|-----------|-----------|
| 1.732 | 60° | about 29° | about 40° |
| 1.000 | 45° | about 28° | about 38° |
| 0.667 | 33°41' | about 26° | about 35° |
| 0.500 | 25°34' | about 25° | about 35° |
| 0.333 | 18°26' | about 25° | about 35° |
| 0.200 | 11°19' | about 25° | about 37° |

| | | | | |
|---|----------|-----------------------|----------|--------------------|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT | Earth Dams: Stability | PROJECT | Design Standard |
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| | CHECKED | | DATE | 4-5-67 PAGE 3 OF 3 |

Seismic Factor

The horizontal acceleration is the primary factor to be considered. The ratio of this acceleration to the acceleration of gravity is the Seismic Factor, or SEIF in the program. Commonly, SEIF = 0.10, and this value shall be used unless a particular earthquake history indicates a greater or lesser value to be appropriate.

The water waves set up by an earthquake are generally small. For example, the wave height resulting from SEIF = 0.1 with a period of 0.25 seconds is on the order of 0.1 to 0.2 foot for a dam 50 feet high. This effect is usually ignored in earth dam stability computations.

| | | | | |
|---|----------|-----------------------|----------|------------------------|
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Assumptions

The following assumptions are made in this procedure for small earth dams:

1. The piezometric gradient of internal pore pressure indicated on the Definition Sketch of page 1 as dh/ds is ignored. This is a substantial stabilizing force which would ordinarily be taken into account in designing higher dams. However, for dams under 100 feet in height, it may be safely ignored in the interests of conservatism and simplified design.

2. No cracks are assumed to exist. The embankment is considered to be homogeneous.

3. There is no problem of rapid drawdown, which is not more than compensated for by ignoring the dh/ds as explained in 1. preceding.

Computer Program

The following pages give the steps in the computer program:

| | | | | |
|---|--------------------------------------|--|---|--|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT <u>Earth Dams: Stability</u> | | PROJECT <u>Design Standard</u> | |
| | COMPUTED <u>Bauer</u> | | FILE NO. _____ | |
| | CHECKED _____ | | DATE <u>4-5-67</u> PAGE <u>5</u> OF _____ | |

```

101. PROGRAM DAMSTA
102. DIMENSION X(20),Y(20),FS(20),XF12(50),YF1(50),YF2(50)
103. READ 0,IFEN,Z,TOPI,XD,ZZ,RA,RE,SHD,SMW,CD,CN,CAND,GAWW
104. THETA=ATAN(Z)
105. RAR=RA/57.295779
106. RRR=RD/57.295779
107. ANG0=3.1415926-THETA-RAR-RRR
108. S1=IFEN/SIN(THETA)
109. S2=S1*SIN(RAR)/SIN(ANG0)
110. X0=S1*COS(THETA)-S2*COS(ARR)
111. Y0=S1*SIN(THETA)+S2*SIN(ARR)
112. PLN=(IFEN+Y0)/(X0-4.5*IFEN)
113. ALB=Y0+X0*(Y0+IFEN)/(4.5*IFEN-X0)
114. XLIN=IFEN/Z+TOPI
115. RFAD 0,N,HW,DELX
116. RFA 0,N,SFIF
117. AM=M
118. NM=N+1
119. HWF=HW-0.767*SIF+SFIF*IFEN
120. PRINT 4,IFEN,TOPI,Z
121. PRINT 5,GAWW,CD,SHD
122. PRINT 5,GAWW,CW,SMW
123. PRINT 11
124. PRINT 7,HW,SFIF
125. PRINT 6,X0,Y0
126. PRINT 1
127. GO TO 28 I=1,N
128. AI=1
129. X(1)=X0-AI*DELX
130. Y(1)=Y0-AI*DFLX+PLN
131. R=X(1)**2+Y(1)**2
132. R=SQRT(R)
133. TFNP1=X(1)/R
134. TEMP2=ABS(TFNP1)
135. IF(TFNP1)20,30,30
136. ANG1=ARCSIN(TFNP2)
137. GO TO 40
138. ANG1=- (ARCSIN(TFNP2))
139. ALPHA=ARCCOS((Y(1)-IFEN)/R)-ANG1
140. FLANG=ALPHA/AN
141. ANGL=0.5*FLANG/2.
142. DIST=0.5*FLANG*R
143. XF12(1)=0.
144. YF1(1)=0.
145. YF2(1)=0.
146. PHI=ANG1
147.
148.

```

| | | | | |
|---|----------|-----------------------|----------|--------------------|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT | Earth Dams: Stability | PROJECT | Design Standard |
| | COMPUTED | Bauer | FILE NO. | |
| | CHECKED | | DATE | 4-5-67 Page 6 of 6 |

SUMH=0.
SUMV=0.
SUMW=0.

149. =
150. =
151. =

152. =
153. =
154. =
155. =
156. =
157. =
158. =
159. =
160. =
161. =
162. =
163. =
164. =
165. =
166. =
167. =
168. =
169. =
170. =
171. =
172. =
173. =
174. =
175. =
176. =
177. =
178. =
179. =
180. =
181. =
182. =
183. =
184. =
185. =
186. =
187. =
188. =

SUMT=0.
DO 26 J=2,101
PHI=PHI+DFLANG
XF12(J)=R+SIN(PHI)+X(1)
YF1(J)=Y(1)-R+COS(PHI)
YF2(J)=YE2(J-1)+(XF12(J)-XF12(J-1))*Z
X1=HW/Z
XX=(XF12(J)+XF12(J-1))/2.
YY=(YX-X1)/(X0-X1)
HWJ=HW*(1.-YY*YY)
IF (XX-X1) 45, 45, 46
45 HWJ=HW
46 IF (YF2(J)-IEM) 60, 60, 50
50 IF (XF12(J)-XLIN) 52, 52, 54
52 YF2(J)=IEM
GO TO 60
54 YF2(J)=IEM-(XF12(J)-XLIN)*Z
60 YY1=(YF1(J-1)+YF1(J))/2.
YY2=(YF2(J-1)+YF2(J))/2.
YDRY=YY2-IWJ
YWFT=IWJ-YY1
IF (YWFT) 70, 70, 80
70 YWFT=0.
YDRY=YY2-YY1
YW=Y(1)-YY1
YD=Y(1)-YY1-YDRY/2.
GO TO 199
80 IF (YDRY) 90, 90, 140
90 YDRY=0.
YWFT=YY2-YY1
YW=Y(1)-YY2+YWFT/2.
YD=Y(1)-YY2
GO TO 199
140 YW=Y(1)-YY1-YWFT/2.
YD=Y(1)-YY2+YDRY/2.
YDRY=YY2-IWJ
YWFT=IWJ-YY1

| | | | | |
|---|----------|-----------------------|----------|--------------------|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT | Earth Dams: Stability | PROJECT | Design Standard |
| | COMPUTED | Bauer | FILE NO. | |
| | CHECKED | | DATE | 4-5-67 Page 7 of 7 |

```

189. =
190. =
191. =
192. =
193. =
194. =
195. =
196. =
197. =
198. =
199. =
200. =
201. =
202. =
203. =
204. =
205. =
206. =
207. =
208. =

199 WFITW=(XF12(J)-XF12(J-1))*YJTT*GAHH
   WFITD=(XF12(J)-XF12(J-1))*YJRY*GAHD
   PHIC=PHI-APHI
   PRFS=(WFITD+WEITW)*(COS(PHIC)-SIF*SIH(PHIC))
   PRFS=PRFS/DIST
   IF(PRFS)170,175,175
170 PRFS=0.
175 IF(VY1-144J)180,180,185
180 SUAT=SUAT+(CH+PRFS*SHW)*DIST*R
   GO TO 190
185 SUAT=SUAT+(CD+PRFS*SHD)*DIST*R
190 SUAT=SUAT+(WFITD+WEITW)*((YF12(J)+XF12(J-1))/2.-Y(1))
   XX=144-144F
   OSUHD=31.2*XX*XX*(Y(1)-144+2.*XX/3.)*31.2*XX*144F*(Y(1)-144F+2.*144F/3.
   4)
   SUHD=SUHD+WEITW*YJ*SCIF+WEITD*YD*SEIF
26 CONTINUE
   FS(1)=SUAT/(SUHD+SUAT+SUHD)
28 PRINT 2,X(1),Y(1),SUAT,SUHD,SUHD,FS(1)
10FORMAT(//,90H X Y FS )
   4 SUHD SUHD FS )
2 FORMAT(2F10.2,4F15.0,F10.3)

209. =
210. =
211. =
212. =
213. =
214. =
215. =
216. =
217. =

40FORMAT(//,10X,20HHEIGHT OF THE DAM = ,F11.1,3H FT/,10X,23HTOP WIN
   1TH OF THE DAM = ,F8.0,3H FT/,10X,19HSLOPE OF THE DAM = ,F4.2,6H
   4TO 1.)
8 FORMAT(//,10X,9HRY SOIL; )
50FORMAT(10X,26HHEIGHT OF THE SOIL = ,F11.2,9H INS/CUFT /,10
   1X,23HCOEFF OF THE SOIL = ,F14.2,9H LRS/SQFT /,10X,23HCOEFF. OF
   4 INTERNAL FRICTION = ,F10.4)
9 FORMAT(10X,9HFT SOIL; )
60FORMAT(//,10X,7HCOORDINATE OF THE CENTER OF THE RUPTURE SURFACE FO
   4R PURE COHESIVE SOIL; /,10X,4HX = ,F12.2/,10X,4HY = ,F12.2)
70FORMAT(10X,14HWATER LEVEL = ,F13.2,3H FT /,10X,17HFSHIC FACTOR
   4= ,F10.2)
11 FORMAT(
   END

```


EXAMPLE FROM LAKE OF-THE-WOODS - JOB # 6692

| | | | | |
|---|----------|-----------------------|----------|-----------------------|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT | Earth Dams: Stability | PROJECT | Design Standard |
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95% AASHO modified
Using the extrap. value
Upstream: 1:3.
(see pages 12 - 14
for selected
Design Values "A")

HEIGHT OF THE DAM = 50.0 FT
TOP WIDTH OF THE DAM = 15. FT
SLOPE OF THE DAM = 0.33 TO 1.

DRY SOIL;
UNIT WEIGHT OF THE SOIL = 115.00 LBS/CUFT
COHESION OF THE SOIL = 250.00 LBS/SQFT
COEF. OF INTERNAL FRICTION = 0.4245

WET SOIL;
UNIT WEIGHT OF THE SOIL = 52.60 LBS/CUFT
COHESION OF THE SOIL = 250.00 LBS/SQFT
COEF. OF INTERNAL FRICTION = 0.4245

WATER LEVEL = 42.50 FT
SEISMIC FACTOR = 0.05

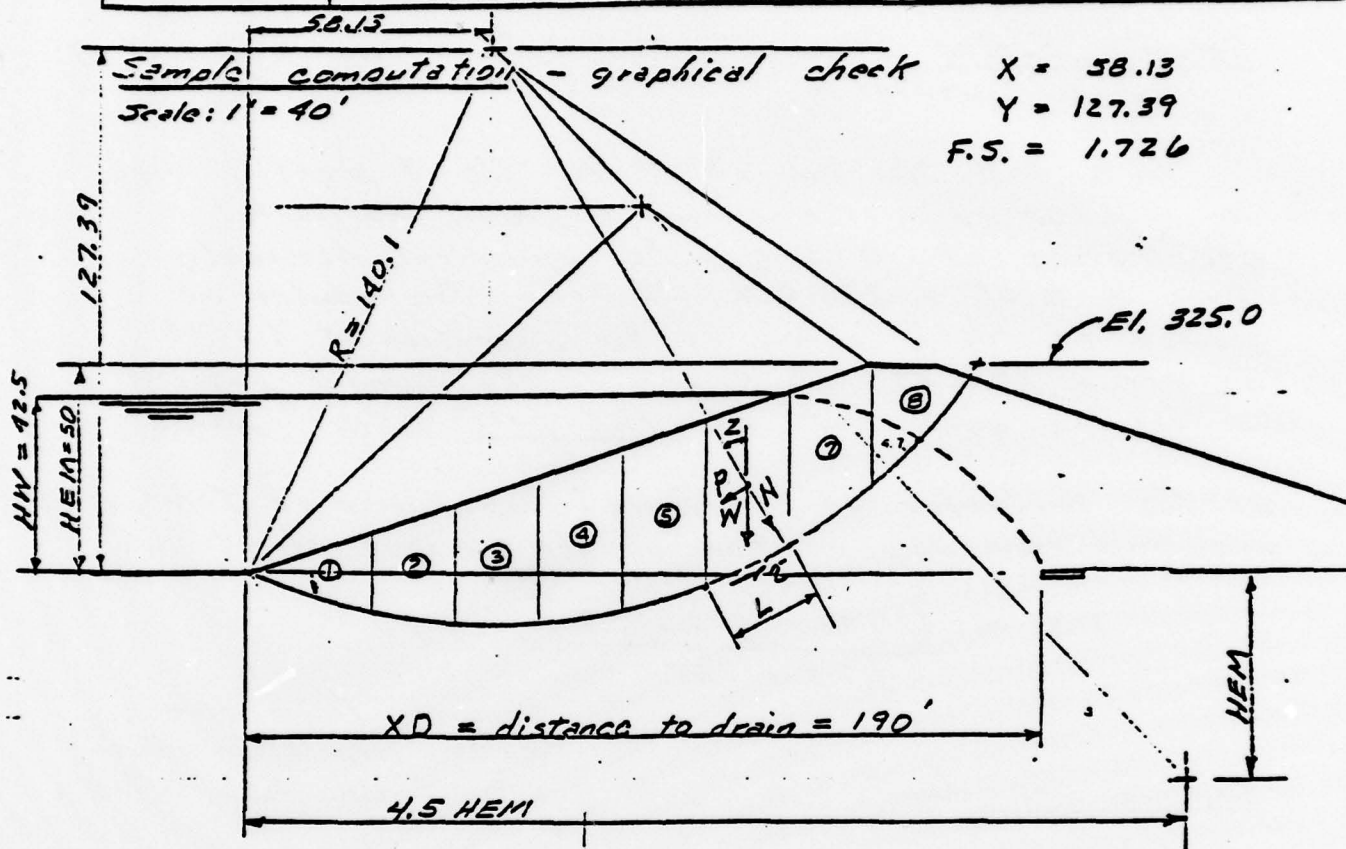
COORDINATE OF THE CENTER OF THE RUPTURE SURFACE FOR PUKE COHESIVE SOIL;

X = 94.13
Y = 89.12

| X | Y | SUMT | SUMW | SUMD | SUMH | FS |
|-------|--------|-----------|-----------|--------|----------|-------|
| 88.13 | 95.50 | 36900281. | 17815673. | 10336. | 2544168. | 1.811 |
| 82.13 | 101.88 | 32594329. | 15679281. | 11147. | 2286410. | 1.813 |
| 76.13 | 108.26 | 29299423. | 14824357. | 11958. | 2080345. | 1.732 |
| 70.13 | 114.63 | 26095905. | 12957792. | 12769. | 1854990. | 1.760 |
| 64.13 | 121.01 | 23465008. | 11809912. | 13579. | 1664365. | 1.740 |
| 58.13 | 127.39 | 21261411. | 10808177. | 14390. | 1494250. | 1.726 |
| 52.13 | 133.77 | 19244232. | 9599124. | 15201. | 1326845. | 1.759 |
| 46.13 | 140.15 | 17505402. | 8521606. | 16012. | 1174232. | 1.802 |
| 40.13 | 146.53 | 15927407. | 7344906. | 16823. | 1026531. | 1.899 |
| 34.13 | 152.90 | 14564660. | 6303823. | 17034. | 892784. | 2.019 |

STATEMENT ENCOUNTERED DURING EXECUTION

| | | | | |
|---|----------|-----------------------|----------|-----------------|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT | Earth Dams: Stability | PROJECT | Design Standard |
| | COMPUTED | Bauer | FILE NO. | |
| | CHECKED | | DATE | 4-5-67 |
| | | | PAGE | 9 |



| Segment → | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-----------------------|----------|-----------|--------|----------|---------|---------|---------|---------|
| ΔX | -38 | -13 | 2 | 22 | 42 | 62 | 82 | 102 |
| ΔY | 127 | 126 | 123 | 119 | 114 | 107 | 97 | 87 |
| $\Delta P / \Delta H$ | -.28/.95 | -.14/1.00 | 0/1.00 | .19/1.00 | .34/.93 | .50/.86 | .64/.76 | .76/.64 |
| 115 52.6 W | 15.7* | 25.0 | 33.0 | 39.0 | 41.5 | 40.0 | 40.7 | 36.0 |
| N | 15.0 | 25.0 | 33.0 | 39.0 | 39.0 | 34.4 | 31.0 | 23.0 |
| P | -4.3 | -3.5 | 0 | 7.0 | 14.0 | 20.0 | 26.5 | 27.5 |
| L | 30 | 20 | 20 | 20 | 21 | 23 | 20 | 30 |
| 250L = C | 7.5 | 5.0 | 5.0 | 5.0 | 5.25 | 5.75 | 6.50 | 7.50 |
| 0.4245 N = T | 6.4 | 10.6 | 14.0 | 16.5 | 16.5 | 14.60 | 13.20 | 9.20 |
| C + T = T | 13.9 | 15.6 | 19.0 | 21.5 | 21.75 | 20.35 | 19.70 | 17.30 |

$$\Sigma P = -7.8 + 95 = 87.2$$

$$\Sigma T = 149.1$$

$$F.S. = \frac{149.1 \times 140.1}{87.2 \times 125} = 1.92$$

VII-19

Compare 1.957 in machine comp.
with seismic factor = 0, p. 11

| | | | | |
|---|----------|-----------------------|----------|-----------------|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT | Earth Dams: Stability | PROJECT | Design Standard |
| | COMPUTED | Bauer | FILE NO. | 4-5-67 |
| | CHECKED | | PAGE | 10 |

Seismic Factor - approximate analysis using preceding Sample Computation.

Note that the sum of W for the 8 slices is equal to 270.9 kips. Assuming a seismic horizontal acceleration of 0.05 g , the equivalent horizontal force = $0.05 \times 270.9 = 13.54^k$. The center of gravity of the 8 slices is by inspection at $Y = 12$, so arm = $127.39 - 12 = 115'$. The moment produced is then the equivalent of $\frac{13.5 \times 115}{140.1} = 11.1^k$ placed

at the perimeter of the circle. The Factor of Safety = F.S. resulting from the addition of the seismic effect is:

$$F.S. = \frac{(149.1 - 11.1) 140.1}{87.2 \times 125} = 1.77$$

Compare 1.726 from machine computation including seismic drawdown effect.

Seismic Drawdown

| Line | α/g Seismic Factor | T Vibration Period | ΔX Horizontal Movement | HEM Embankment Height | ΔHW Seismic Drawdown |
|------|------------------------------|-----------------------|-----------------------------------|--------------------------|---------------------------------|
| 1 | 0.10 | 0.25 sec. | 0.012' | 50' | 0.13' |
| 2 | 0.05 | 0.25 sec. | 0.006' | 50' | 0.065' |

$$Force = 25' \times .065 \times .0625 = 0.1^k - \text{neglect.}$$

AD-A073 631

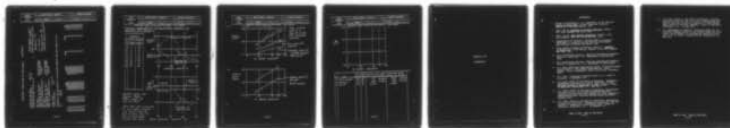
BAKER (MICHAEL) JR INC BEAVER PA
NATIONAL DAM SAFETY PROGRAM. LAKE OF THE WOODS, INVENTORY NUMBE--ETC(U)
MAR 79 M BAKER DACW65-78-D-0016

F/G 13/2

UNCLASSIFIED

3 OF 3

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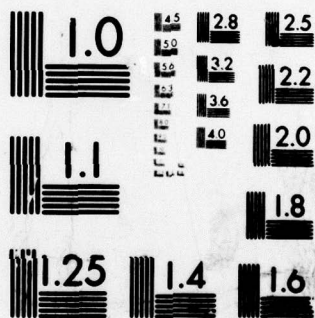


END
DATE
FILMED

10-19

DOC

NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

EXAMPLE FROM LAKE OF THE WOODS, JOB #6692

HEIGHT OF THE DAM = 50.0 FT
 TOP WIDTH OF THE DAM = 15. FT
 SLOPE OF THE DAM = 0.33 TO 1.

DRY SOIL;
 UNIT WEIGHT OF THE SOIL = 115.00 LBS/CUFT
 CONESION OF THE SOIL = 250.00 LBS/SQFT
 COEF. OF INTERNAL FRICTION = 0.4245
 WET SOIL;
 UNIT WEIGHT OF THE SOIL = 52.60 LBS/CUFT
 CONESION OF THE SOIL = 250.00 LBS/SQFT
 COEF. OF INTERNAL FRICTION = 0.4245

WATER LEVEL = 42.50 FT
 SEISHIC FACTOR = 0.

COORDINATE OF THE CENTER OF THE RUPTURE SURFACE FOR PURE COHESIVE SOIL;

X = 94.13
 Y = 89.12

| X | Y | SUMT | SUMW | SUMH | FS |
|-------|--------|-----------|-----------|------|-------|
| 88.13 | 95.50 | 37699266. | 18590618. | 0. | 2.028 |
| 82.13 | 101.88 | 33200767. | 16173505. | 0. | 2.053 |
| 76.13 | 108.26 | 29848563. | 15300947. | 0. | 1.951 |
| 70.13 | 114.64 | 26635390. | 13553688. | 0. | 1.965 |
| 64.13 | 121.01 | 23888076. | 12189094. | 0. | 1.960 |
| 58.13 | 127.39 | 21599294. | 11039205. | 0. | 1.957 |
| 52.13 | 133.77 | 19510907. | 9729184. | 0. | 2.005 |
| 46.13 | 140.15 | 17719382. | 8587697. | 0. | 2.063 |
| 40.13 | 146.53 | 16099470. | 7375119. | 0. | 2.183 |
| 34.13 | 152.91 | 14704565. | 6313731. | 0. | 2.329 |

95% AASHTO modified
 using extrapolated values
 Upstream 1:3
 no seismic.
 (see pages 12-14 for "A"
 selected design values)

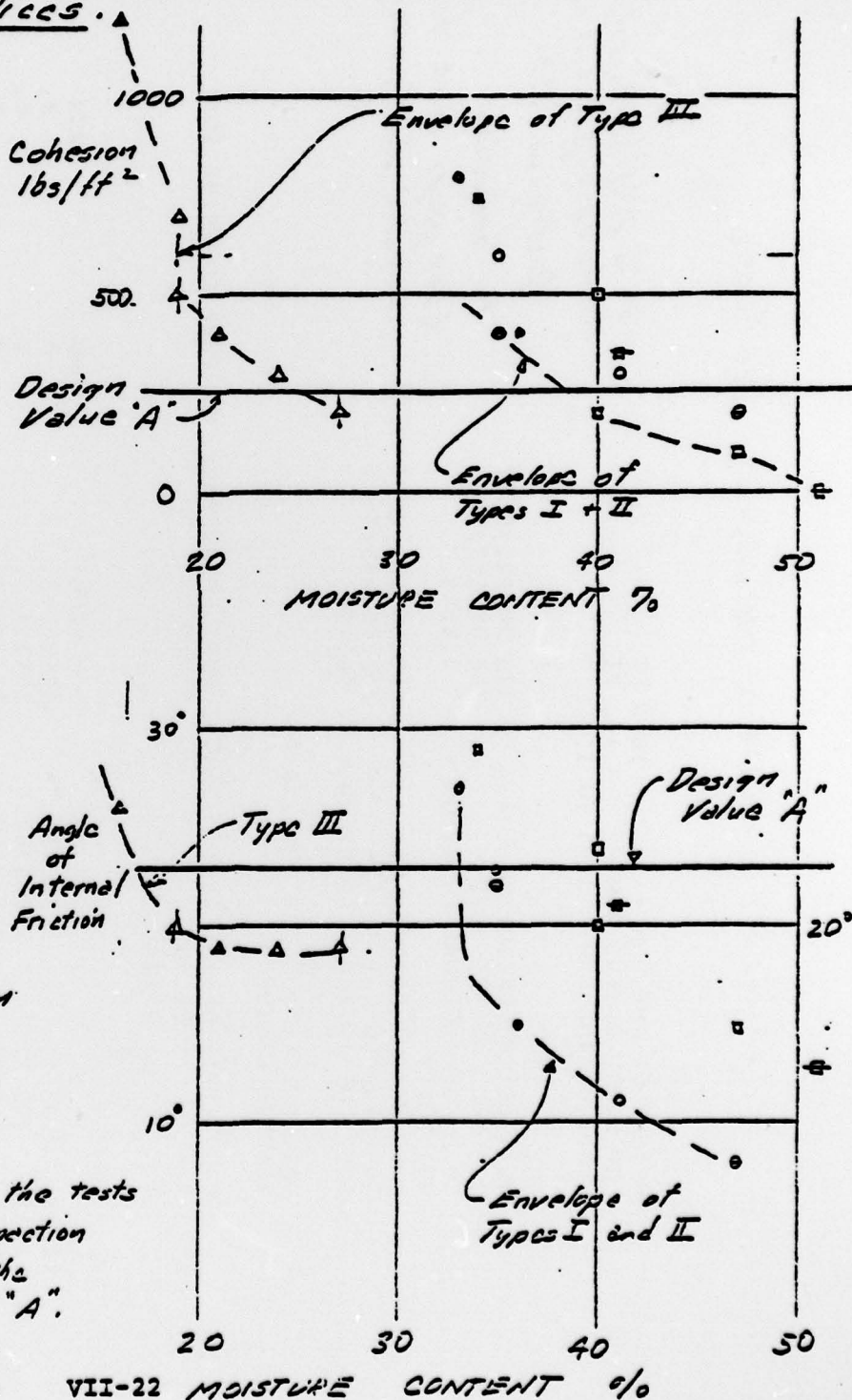
| | | | | |
|---|----------|-----------------------|----------|----------------------|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT | Earth Dams: Stability | PROJECT | Design Standard |
| | COMPUTED | Bauer | FILE NO. | |
| | CHECKED | | DATE | 4-5-67 Page 11 of 14 |

| | | | | |
|---|----------|-----------------------|----------|-------------------------|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT | Earth Dams; Stability | PROJECT | Design Standard |
| | COMPUTED | Bauer | FILE NO. | |
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EXAMPLE FROM LAKE-OF-THE-WOODS - JOB #6652

Sample computation of earth-dam stability by method of slices.

| LEGEND | | |
|--------|-----------|---------------|
| Symbol | SOIL TYPE | % COMP. AASHO |
| • | I | 90 |
| ○ | I | 83 |
| ⊙ | I | 78 |
| ■ | II | 90 |
| □ | II | 82 |
| ⊠ | II | 78 |
| ▲ | III | 90 |
| △ | III | 86 |
| ⬆ | III | 82 |



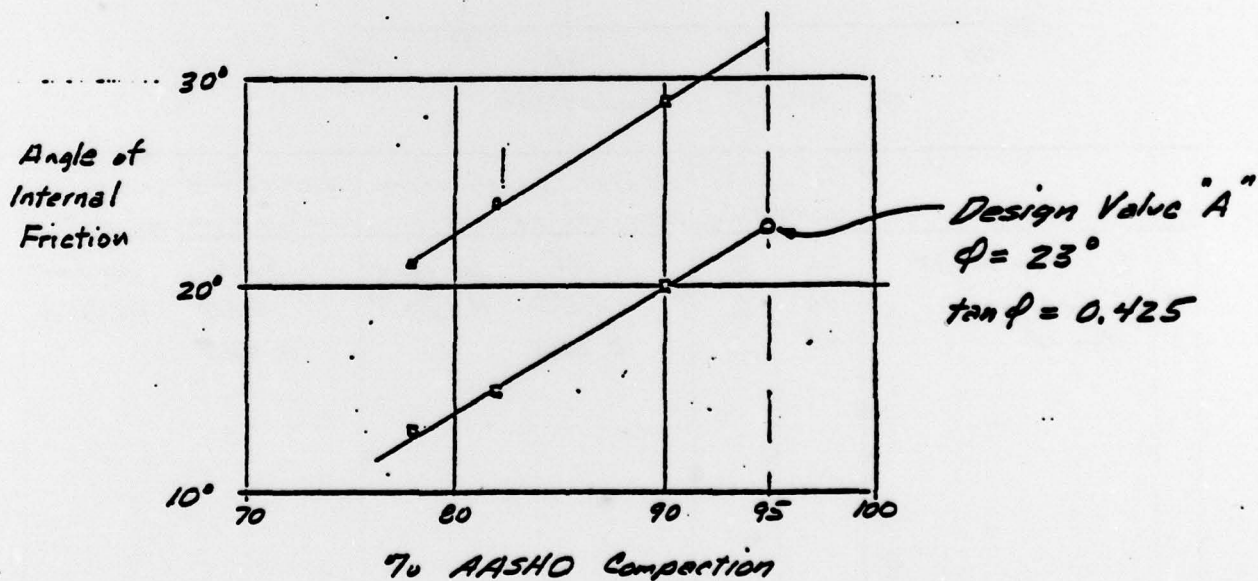
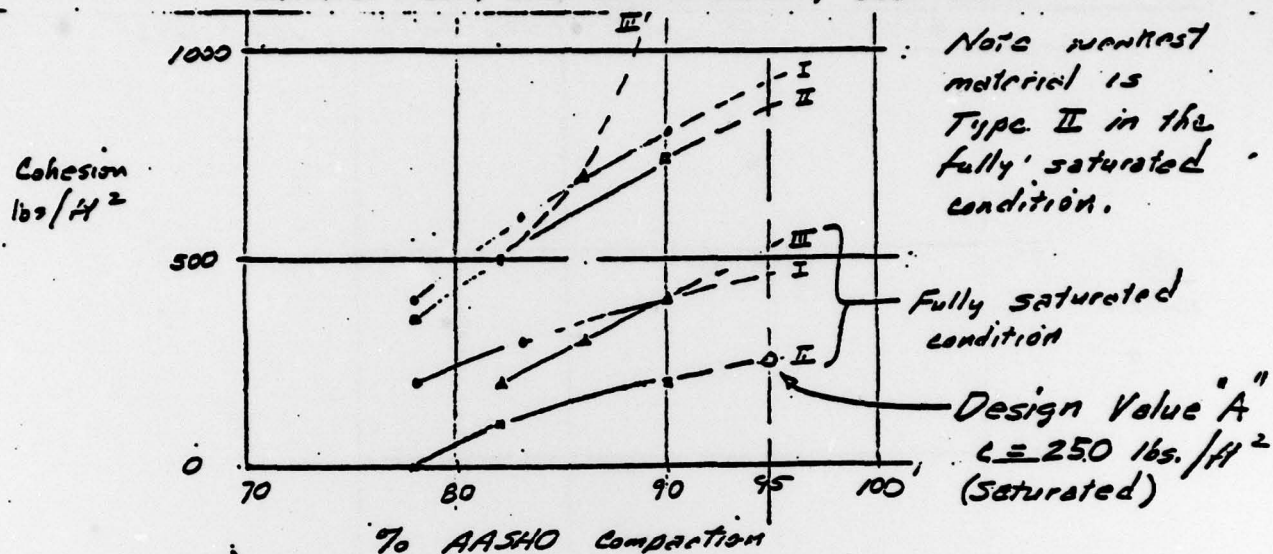
Plotted points from
Dames + Moore
letter report of
Jan. 31, 1967.

Note that most of the tests
for 90% AASHO compaction
give results above the
levels of Design Value "A".
Only saturated samples
lie below these values.

VII-22 MOISTURE CONTENT %

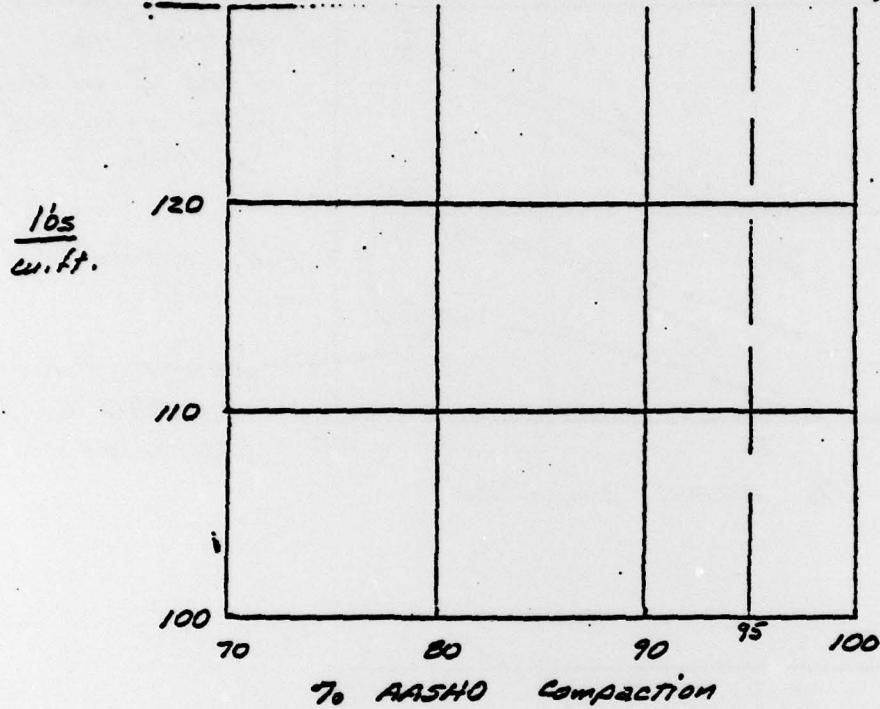
| | | | | |
|---|----------|-----------------------|----------|-------------------------|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT | Earth Dams: Stability | PROJECT | Design Standard |
| | COMPUTED | Bauer | FILE NO. | |
| | CHECKED | | DATE | 4-5-67 Page 13 of Pages |

EXAMPLE FROM LAKE-OF-THE-WOODS, JOB # 669L



| | | |
|---|--------------------------------------|--|
| BAUER ENGINEERING INC. CHICAGO | SUBJECT <u>Earth Dams: Stability</u> | PROJECT <u>Design Standard</u> |
| | COMPUTED <u>Bauer</u> | FILE NO. _____ |
| | CHECKED _____ | DATE <u>4-5-67</u> PAGE <u>14</u> OF _____ PAGES |

EXAMPLES FROM LAKES-OF-THE-WOODS, JOB #6692



| # | Item | % AASHTO | Soil Type | Moist earth above line of saturation | Saturated earth below line of sat. |
|---|-------------|-------------|--------------|---|---------------------------------------|
| 1 | Unit weight | 95 | II | 115 lbs./cu.ft. | 52.6 lbs./cu.ft. |
| 2 | Cohesion | 95 | II | 850 lbs./sq.ft. | 250 lbs./sq.ft. |
| 3 | Tan ϕ | 95 | II | 0.625 | 0.425 |

APPENDIX VIII

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REFERENCES

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VIII-1

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VIII-2